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U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN No. 42.

L. O. HOWARD, CHIEF OF DIVISION.

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SOME INSECTS ATTACKING THE STEMS OF GROWING WHEAT, RYE, BARLEY, AND OATS,

WITH

METHODS OF PREVENTION AND SUPPRESSION.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY

F. M. WEBSTER, M. S.,

Special Field Agent.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Division of Entomology,
Washington, D. C., September 25, 1903.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled "Some insects attacking the stems of growing wheat, rye, barley, and oats," prepared under my direction by Prof. Francis M. Webster, temporary field agent of the Division of Entomology, and now stationed at Urbana, Ill. Professor Webster has acted as field agent of this Division, having received temporary appointment since 1884, with headquarters at the experiment stations of Indiana, Ohio, and Illinois, and is ably qualified for the prosecution of the present work through years of study in the States mentioned of the insects which will be treated. As remarked in the introduction, this paper deals with the injuries committed to small grains by different forms of minute flies, eight species in all, which are generally confused by the average farmer with the Hessian fly. The differences between these various species and their method of attack in comparison with that of the Hessian fly are duly pointed out, and many valuable suggestions based upon an intimate knowledge of the habits of these insects are made for the mitigation of their ravages. In most instances losses by these insects could be prevented by the simplest of farming practices, as set forth in their proper place. I recommend the publication of this report as Bulletin No. 42 of this Division. The fifteen text figures are necessary for the purposes of illustration, those illustrating plants having been kindly loaned by the office of Agrostologist.

Respectfully,

L. O. Howard,
Entomologist and Chief.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 7
The genus Isosoma 9
Dealing with the destructive species outside of the grain fields 11
The greater wheat straw-worm (*Isosoma grande* Riley) 14
Previous record of the insect 14
Discovery of the summer form 15
Discovery of dimorphism and alternation of generations 16
Riley's name, *Isosoma tritici*, invalid 17
Life history 17
Oviposition of the spring form (*minutum*) 18
Oviposition of the summer form (*grande*) 19
Description 21
Adults of summer form (*Isosoma grande* Riley) 21
Larva, pupa, and egg of summer form 21
Adults of spring form (*Isosoma minutum*) 21
Larva and pupa of spring form 21
Natural enemies 22
Preventive and remedial measures 22
Distribution 23
The joint worm (*Isosoma tritici* Fitch) 23
Previous record of the insect 24
Life history 26
Distribution 26
Description 27
Adult female 27
Adult male 27
Natural enemies 27
Remedial and preventive measures 28
Difficulty in recognizing the species 28
The barley straw-worm (*Isosoma hordei* Harris) 29
Previous records of the insect 29
Life history 31
Effect of the larvæ on the plant 31
Description 32
Adult female 32
Adult male 32
Natural enemies 33
Preventive measures 33
The captive Isosoma (*Isosoma captivum* How.) 34
Description 34
Adult female 34
Adult male 35

The genus Isosoma—Continued. Page.
Webster's Isosoma (*Isosoma websteri* How.) 35
Description of adult female 36
The hairy-faced Isosoma (*Isosoma hirtifrons* How.) 36
Description of adult female 37
Isosoma secale Fitch 38
Description 38
Adult female 38
Adult male 38
Fitch's Isosoma (*Isosoma fitchii* How.) 39
Description 39
Adult female 39
Adult male 39
The two-winged grain and grass flies 40
Were probably originally grass feeders 41
Early reports of injuries to grain 42
The greater wheat stem-maggot (*Meromyza americana* Fitch) 43
Past history of the insect 43
Life history 46
Description 47
Adult fly, egg, larva, and pupa 47
Food plants 47
Selection of food plants by the adults 48
Place and method of oviposition 48
Method and nature of attack 49
Extent of ravages 50
Preventive measures 50
Natural enemies 51
The lesser wheat stem-maggot (*Oscinis carbonaria* Loew) 51
Life history 52
Food plants 53
Place and method of oviposition 53
Nature of injury 53
Extent of ravages 54
Description of adult 54
Close resemblance to *Oscinis soror* Macq 55
Description of egg, larva, and pupa 55
Preventive measures 56
Natural enemies 56
The American frit-fly (*Oscinis soror* Macq.) 57
Confusion with other species 57
Depredations in Minnesota 58
Life history 59
Food plants 60
Difficulties in studying habits 60
Remedial and preventive measures 61
Description 61
Conclusion 62

ILLUSTRATIONS.

Page.

FIG 1. Canadian rye grass (*Elymus canadensis*) 12
2. Virginia rye grass (*Elymus virginicus*) 13
3. Greater wheat straw-worm (*Isosoma grande* Riley), spring generation, form *minutum;* stages 14
4. Greater wheat straw-worm (*Isosoma grande* Riley), adult summer form. 14
5. Head of wheat partly destroyed by *Isosoma minutum* 18
6. Method of oviposition of female of summer form (*I. grande*); *b*, point in straw where egg is placed 20
7. *Pediculoides ventricosus* Newp., a mite which destroys the larva 22
8. *Isosoma tritici* Fitch; adult of the joint worm 24
9. Effect of joint worm in wheat straw 25
10. *Isosoma hordei* Harr.; adult of the barley straw-worm 30
11. *Isosoma captivum* How.; adult 34
12. *Isosoma websteri* How.; adult female 35
13. *Isosoma hirtifrons* How.; adult female 37
14. Greater wheat stem-maggot (*Meromyza americana* Fitch); stages and effect on young wheat plant 44
15. *Oscinis soror* Macq., stages; *d*, head of *Oscinis carbonaria* 52

SOME INSECTS ATTACKING THE STEMS OF GROWING WHEAT, RYE, BARLEY, AND OATS.

INTRODUCTION.

Throughout the United States, where the smaller cereal grains—wheat, rye, barley, and oats—are to any considerable extent cultivated, a multitude of injuries to growing wheat are charged by the average farmer to the Hessian fly; whereas, in many cases these ravages are really the work of insects whose habits differ greatly from those of that insect. Indeed, some of them are not flies at all, and even where the ravages are caused by flies, these are not necessarily the Hessian fly, and the same remedial and preventive measures that are applicable to this notorious wheat pest may not be at all effective against them. In fact, it is with the hope of enabling the farmer, as also the economic student, to distinguish between some of the chief insect enemies of cereal grains, and especially between many of them and the Hessian fly, that this publication has been prepared.

In the following pages the author has restricted himself to the consideration of two groups of grain-affecting insects, the one composed of true flies, and the other not, though both during their developmental stages live and thrive within the stems of wheat, and to some extent within those of the growing grasses as well. Indeed, as a whole, they were doubtless primarily grass feeders, and their grain-attacking habits, being of more recent origin, brought about by the changed conditions of their natural food supply, consequent upon the influences of advancing civilization, may be looked upon as a modification of their original methods of living.

While this variety of food plants, including the wild grasses, as well as the cultivated grains, probably has the effect of more generally diffusing some of these insects, thus rendering serious outbreaks of less frequent occurrence, the other phase of the problem is that though the farmer might exterminate them from his fields, they would still inhabit the grass lands and from there continually send a fresh supply of colonists into his fields to repopulate them. But, again, this has its redeeming features, as it enables the grain grower, in some cases, to meet his enemies in the grasses and there fight them to better advantage to himself than in his cultivated fields. The Hessian fly is

an exception, as it has yet to be found attacking the grasses in this country; yet several insects whose injuries in the wheat fields have been charged up to it by the farmer may be destroyed to a greater or less extent by closely pasturing the roadsides and fence corners in summer or burning them over in winter or early spring.

The first group of these grain-attacking insects to which attention will be here given is composed of those that are not flies at all in the true sense of the term, but small ant-like creatures, really related to the ants which they so closely resemble. Their young live within the stems of the smaller cereal grains and grasses, and, though these rarely kill the wheat stems outright, they may either prevent the production of the kernels or cause these last to shrink and shrivel, thereby greatly reducing them both in weight and market value. These insects are called the grain and grass Isosomas, and their young are the wheat straw-worms and the joint-worms. What is still more surprising, they belong to a group of insects the majority of which are not vegetable feeders, but parasitic on other insects, and it was a long time before entomologists were willing to accept the fact that they were the real depredators and not parasites. This doubt as to the real food habits of these insects had not entirely disappeared up to 1884, when the author proved by successive rearings not only the vegetal habits of one of the species, but also the even more interesting fact of dimorphism and an alternation of generations, showing that what appeared to be two species was really two generations of one of them; but one of the generations, being wingless in the adult stage, renders it the more easily controlled by the farmer through a rotation of crop.[a]

The second group of insects here considered is composed of true flies, and these also are both grain and grass feeders in the larval or maggot stage. All true flies have but two wings, and the maggots have no jaws, but the mouth parts consist of two minute hooks whereby they tear or slightly wound the surface of the tender stems and suck the juices flowing therefrom. The Hessian fly is also a true fly, but its form partakes more of that of the mosquito, while these under consideration have very much the form of the common house fly, except that they are smaller, and they are frequently quite differently colored. The maggot of the Hessian fly is larger and more robust than are those of the Oscinids, though shorter and differing in color from those of Meromyza.

Judging from my own experience and observation, these insects are much more injurious to the young grain plants. One brood of maggots of Meromyza work in the full-grown straw it is true, but, as a rule, the injury at that time is seldom very severe, while the larvæ of the Oscinids are rarely found in the full-grown straw, except in the

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[a] Reports U. S. Comm. Agr., 1884, pp. 383–387; 1885, pp. 311–315; 1886, pp. 573–574.

extreme north, notably in Minnesota, and in Manitoba and the Northwest Territories in Canada. The Isosomas do not attack the grain plants in the fall, and thus we have a natural division between the two, which is applied in the discussion of these insects in the following pages.

The Oscinids are not destructive in this country alone, as allied species have long been a serious pest in England, France, Germany, and Sweden. The frit-fly (*Oscinis frit* Linn.), is some years especially destructive in Europe. The gout-fly (*Chlorops tæniopus* Meigen) and the wheat bulb-fly (*Hylemyia coarctata* Fallen) are both more or less injurious to small-grain crops in England.

In the preparation of this bulletin the writer has been greatly aided by Dr. Howard and his corps of assistants, both in the Department of Agriculture and also in the United States National Museum, and by Dr. S. A. Forbes in kindly and promptly placing the notes and collections of the Illinois State Laboratory of Natural History at the author's disposal. The writer is also indebted for specimens to Dr. James Fletcher, entomologist and botanist for the Dominion of Canada, and for similar favors received from Prof. F. L. Washburn, State entomologist of Minnesota.

THE GENUS ISOSOMA.

The grass and grain joint-worm flies belonging to this genus are widely distributed in America, some of the most important ranging from the Atlantic to the Pacific coasts and from Canada southward probably as far as the grains, wheat, rye, and barley are grown.

The genus Isosoma is known to inhabit Europe, Africa, Madeira, St. Vincent, Australia, and Tasmania. In Europe it ranges over Russia, Switzerland, Germany, Austria, and Italy. When the insect faunas of Asia and Central and South America come to be better understood, we shall in all probability find that species occur in those countries also.

These insects belong to the Chalcididæ, a family of parasites whose normal food is other insects in one or more stages of their development. For a long time entomologists refused to believe that the species of Isosoma and their allies were exceptions to this supposed rule, and Harris firmly believed that *Isosoma hordei* was a parasite and not the true depredator in barley straw. Dr. Asa Fitch afterwards established the fact of phytophagic habits in *I. hordei* as well as in several other species, but English and European entomologists were not wholly convinced, at least not all of them, up to as late as 1882. When the writer began the study of grain-infesting Isosoma in 1884, comparatively little was known of the habits of some of our most common species, and the establishing of the fact of dimorphism

and alternation of generations by him in the case of *Isosoma tritici* Riley, as it was then known, and *I. grande* was without a parallel, in this genus, and so remains in this country. Among the ten or twelve American species that I have reared, none of the others, so far as I have been able to determine, enter the pupal stage in the fall and winter in that condition,[a] and thus the greater wheat straw-worm (*Isosoma grande*) is one stage in advance of the others in spring, and the spring form, *minuta*, is developed at the time when other species are entering the pupal stage. This is also the only species that I have not succeeded in rearing from food plants other than wheat, with the possible exception of *Isosoma websteri*, which might have been reared from young cheat plants, though I hardly think this probable. The fact that I have only found this latter species in spring, and then only females, is indicative of a dimorphism and alternation of generations; but unless it be an undescribed species reared from stems of *Tricuspis sesleroides*, which is very late to mature, being even later than any other species known to me, I do not think such alternation can be connected with any other species that I have studied. On the other hand, and at the other extreme in the matter of food plants, the Elymus Isosoma (*I. elymi* French), has never been with certainty reared from wheat, though abundantly from the stems of cheat growing among wheat and from Elymus growing along the margins of wheat fields.

I also find, much to my surprise, that I have reared Fitch's *Isosoma tritici* aside from its known food plant, wheat, only from *Elymus virginicus*. Even where this latter grass and the closely allied *E. canadensis* have grown side by side, the joint worm (*Isosoma tritici* Fitch) has held strictly to the former. The white-spotted Isosoma (*I. albomaculata* Ashmead), perhaps the most closely allied to *I. grande* of any of the species known to me, and which we should suppose would more than any other incline to dimorphism and alternation of generations, seems, however, to show no such tendency, and, moreover, I have reared it from both cheat and *Elymus virginicus*, the life cycle, so far as I have been able to follow it, being parallel with those of *Isosoma elymi*, *I. tritici*, and *I. hordei*. I do not, of course, wish to obscure the possibility of an alternation of generations among these insects, with a different food plant for each generation. On the opposite page is given in tabulated form the food plants of the species of Isosoma known to attack grains and grasses in North America.

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[a] Should the observations of Dr. Andrew Nichols, given under *Isosoma hordei*, prove correct, this may in future prove erroneous as to *I. grande*, unless the latter also attacks barley.—F. M. W.

	I. grande.	I. hordei.	I. tritici.	I. hirtifrons.	I. websteri.	I. secale.	I. elymi.	I. captivum.	I. maculatum.	I. albomaculatum.	I. bromi.	I. hageni.	I. agrostidis.	I. bromicola.	I. fitchii.	I. californicum.
Wheat	×	....	×	....	×	×?	....	....	....	....	....	....	....	....	×?	....
Rye	....	×?	×	×	....	×	....	×?	....	....	....	....	....	....	×?	....
Barley	×?	×	×?	....	....	×?	....	....	....	....	....	....	....	....	×?	....
Elymus virginicus	....	....	×	....	....	....	×	....	....	×	....	....	....	....	....	....
Elymus canadensis	....	×	....	....	....	....	×	....	....	....	....	....	....	....	....	....
Cheat	....	....	....	×	....	....	×	....	×	×	....	....	....	....	....	....
Bromus ciliatus	....	....	....	....	....	....	....	....	....	....	×	....	....	×	....	....
Eriocoma cuspidata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×?
Agrostis sp. ?	....	....	....	....	....	....	....	....	....	....	....	....	×	....	....	....
Quack grass	....	....	....	....	....	....	....	....	....	....	....	×	....	....	....	....

DEALING WITH THE DESTRUCTIVE SPECIES OUTSIDE OF THE GRAIN FIELDS.

In attempting to control the grain-infesting Isosoma, the practical farmer will, in several ways, find himself at a disadvantage. The very deceptive resemblance of these insects to ants, and also to others actually beneficial, will prevent his readily recognizing them in the fields, even if he were to see them at all, and it is only when, by accident, perhaps, that he finds the worms in the stems of his grain, that he will ordinarily be able to detect their presence. As the development of the insect takes place entirely within the straw, rarely, except in the case of two species, showing any external effects, much injury may occur to the kernels of grain without his being able to determine the cause. It is, therefore, advantageous to him to know that he may reduce the chances of injury by careful attention to the uncultivated areas that inevitably surround his cultivated fields. As an illustration of the influence of neglecting uncultivated patches like fence corners and roadsides, and allowing these to become overgrown with the different species of rye grass (Elymus), I give the results of my own rearings of these insects from stems of grasses, taken from two different localities along the Illinois Central Railway. In connection with what is here given, it might be well to call attention to the fact that the grounds within the fences along our more important railways are usually better kept than are similar uncultivated grounds along the highways, to say nothing of the fence corners, borders of open ditches, and similar tracts on the premises of the farmers themselves.

The locality from which I secured the greatest number of barley straw-worm flies (*Isosoma hordei*) is situated about 2 miles north of Champaign, Ill. The contour of the ground is such that mowing over in summer is difficult, and burning over in winter, though practical, probably did not seem necessary to the railway people. As a consequence, a small tract grew up to the Canadian rye grass (*Elymus*

canadensis, fig. 1), the stems of which literally swarmed with the larvæ of this species. It beyond question would have furnished enough adults to have stocked hundreds of acres of barley had it been within reach. The presence of the old stems clearly indicated that the place had been neglected for years, and grass stems of the previous year were filled with punctures where the adults had made their escape. Without anyone knowing it, there was here kept a perpetual nursery for barley straw-worm flies, and though not at present a barley country, it is true, it is easy to see what the effects would be were the situation otherwise and must be elsewhere where this grain is more largely grown.

The locality from which I secured the least number of these insects, and, in fact, none of the grain-attacking species at all, is located along the same railway, in the edge of the village of Peotone, Ill. Here the topography of the ground along the railway is even worse than that in the Champaign locality, but close proximity to the village rendered more attention to it necessary. I am informed by those living near the place that it is regularly mown off during the latter part of June and again in September. The material used in my breeding experiments was collected August 12 at Champaign and August 21 at Peotone, and, though the Canadian rye grass was much more abundant in the latter locality, and to all outward appearances at the time the material was secured offered the joint-worms a far superior place to develop there, yet with ample material I did not obtain a single individual, though in Dekalb County, about 60 miles west of Chicago, where, to my certain knowledge, no wheat or barley has been sown for years, from grass collected August 20 I reared quite a number of these insects. The Dekalb County material was collected from along the neglected roadsides in the country. I can see no possible explanation of the difference in abundance of the joint-worms in the rye grass secured at Champaign and that secured at Peotone, except the difference in the attention given to mowing off the grass during the summer—the same attention that farmers can without trouble give to the roadsides, fence corners, and ditch borders on and about their own premises. These things are a part of good husbandry, yet among intelligent farmers I have found the two species of rye grass growing not only by the roadsides, but along the very borders of their wheat fields, in some cases the grass and wheat being intermixed along the extreme edges of the fields of grain.

FIG. 1.—Canadian rye grass (*Elymus canadensis*), (after Scribner).

Under much the same conditions I have reared the greatest numbers of joint-worm flies, at present known as *Isosoma tritici* Fitch, from the Virginia rye-grass (*Elymus virginicus*, fig. 2). In this case the grass from which I secured these insects in greatest profusion came from the most neglected roadsides. In the vicinity of the city of Urbana, Ill., I secured material from two localities, one quite near the resident quarter, where the city government required the mowing off of weeds and grasses, commencing in June, and the other farther from town, along a neglected bank where the grass was allowed to grow up undisturbed year after year. From grass stems from the former locality I secured almost nothing, while from that coming from the latter locality I obtained enough to show that there was here a constant menace to the wheat fields in the neighborhood. Now, as a matter of fact, there is comparatively little wheat or rye grown in the neighborhood, and until I reared these insects from the wild grasses I could not account for their sudden appearance in the wheat and rye fields, observed and recorded in former years by Professor Forbes and his assistants. What has proven true here has been shown to follow similar conditions elsewhere in both Illinois and Indiana. That is to say, where farmers have allowed these grasses to grow up about their farms year after year under the impression that they were not worth any attention, I have found the insects in abundance, and also find that despite their otherwise good farming, they have probably suffered more or less from the attacks of the two species of destructive Isosoma in their grain, though they may not have observed them or their subtile effects on the kernels of the wheat and rye. I am convinced that there is an element of loss here of which farmers are unaware and the precise effects of which they do not therefore comprehend, yet might if they realized the situation.

FIG. 2.—Virginia rye grass (*Elymus virginicus*) (after Scribner).

THE GREATER WHEAT STRAW-WORM.

(*Isosoma grande* Riley. Fig. 3, form *minuta;* fig. 4, form *grande.*)

PREVIOUS RECORD OF THE INSECT.

The history of this species extends back only to 1880, though it was probably for many years confused in wheat with the joint-worm. It sometimes occurs that insects which the systematist can only consider distinct prove on thorough study to belong to one and the same

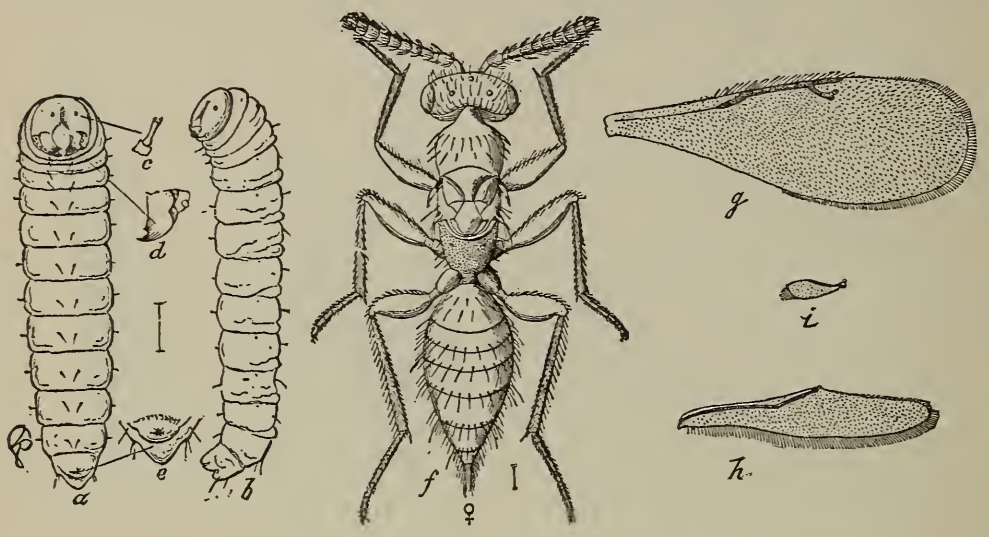

FIG. 3.—Greater wheat straw-worm (*Isosoma grande* Riley), spring generation, form *minutum: a, b,* larva; *f,* female; *g,* fore-wing; *h,* hind-wing; all much enlarged (from Riley).

species, while, on the other hand, it sometimes occurs that what the systematic entomologist considers the same species prove on investigation to be entirely different, and thus the problem of control, if injurious, is either simplified or complicated, as the case may be. However easy it may appear to the farmer, to learn all of the life history of an insect is not unfrequently a matter of no little difficulty. Where we can follow out the life cycle of a species accurately, there is usually found some place or period in its existence when it is more easily controlled or destroyed than at any other time, and it often occurs that at the critical point some simple manipulation of his land or his crop, on the part of the farmer, will accomplish wonders. This species seems to offer illustrations of all of these features.

FIG. 4.—Greater wheat straw-worm (*Isosoma grande* Riley), adult summer form, much enlarged (from Howard).

In June, 1880, Mr. J. K. P. Wallace, of Andersonville, Tenn., sent to Dr. C. V. Riley a number of wheat straws containing larvæ, with the complaint that nearly every stalk or straw was affected by them, and, as a consequence, the straw was inclined to fall before the grain had fully ripened. Mr. J. G. Barlow, of Cadet, Mo., about this time also complained of a similar trouble in his neighborhood, in some cases resulting in nearly a total loss of the crop. In the winter of 1881–82, Dr. Riley was able to rear some 30 adults from these infested straws, and, as he considered the species described by Dr. Fitch only a variety of the barley straw-worm (*Isosoma hordei* Harris), he described the adults obtained from these straws as *Isosoma tritici* Riley, which description was published in the Rural New Yorker March 4, 1882. This was the situation and the condition of our knowledge of the species at the time the writer was appointed a special agent of the Division of Entomology, of which Dr. Riley was then chief, and under his instructions began the study of these and other grain insects in May, 1884.

DISCOVERY OF THE SUMMER FORM.

On May 8, 1884, in a field of wheat near Bloomington, Ill., I found *Isosoma tritici* Riley, as it was at that time known, in considerable numbers, crawling over the young wheat plants, and on the 11th of the same month watched a couple of females deposit their eggs in these growing plants. On May 30, while examining plants from this same wheat field, young Isosoma larvæ were found in the stems, and I also found larvæ in the stems in which I had observed the captured females to oviposit May 11, but these last were much too large for *Isosoma tritici*. During the previous few days I had been getting from fields of both wheat and rye in the same locality a much larger Isosoma, possessing fully developed wings, and on May 29 a pupa, also too large for *I. tritici*, was found in the upper part of a dwarfed wheat plant. In the light of more recent studies we now know that I had three species under observation instead of one. The small individuals found early in the month of April belonged to the spring form of this species, and others were *Isosoma websteri*, while the larger individuals swept from wheat and rye, later in the month of May, were some of them the summer form (*I. grande*), and others belonged to another species, afterwards described as *Isosoma captivum* Howard. My field of observation was at this time transferred from Bloomington, Ill., to Oxford, Ind.

On June 6, in a field of wheat near Oxford, I observed female Isosomas, seemingly like those taken a few days before in the wheat and rye fields near Bloomington, ovipositing in wheat plants, well up toward the top of the stem, probably between the upper joint and the one next below, although, on account of the head of the wheat having not yet put forth, it seemed as though the egg was being placed in the

upper joint. A large number of these adult females were secured, and these constituted the types upon which the description of *Isosoma grande* was based.[a]

DISCOVERY OF DIMORPHISM AND ALTERNATION OF GENERATIONS.

At harvest I arranged with the owner of the field near Oxford to allow a small area where I had witnessed the oviposition of the female Isosomas to remain uncut, and I afterwards secured these straws, a part being kept out of doors and the remainder kept within doors during the following winter. Some conception of the extent to which these straws were tenanted by the larvæ of this species may be gained by the fact that of 90 straws from the same field 81 were infested and contained 136 larvæ. These straws were cut close to the ground, and, therefore, the contained larvæ represented the total number. Of 90 straws as cut by the harvester, there were a far less number of larvæ present, only 25 being found in the entire lot, the remainder having been left in the stubble.

By October all of the larvæ had pupated, and my first adult was obtained December 7 from the lot of straws kept indoors. From this time on till June I continued to secure adults issuing from these straws, but everyone of them were *Isosoma tritici* Riley. All of the straws were now split open in order to determine whether or not any individuals still remained, but none were found.

My first adult from the straws kept out of doors appeared March 23, and others continued to appear up to the first week in April, all, as with the straws kept indoors, being *Isosoma tritici* Riley. These straws were now split open and examined, but there was no trace of *Isosoma grande*, which I knew had deposited eggs in these very straws. Despite all this, on June 1, in sweeping the grass along the borders of a wheat field at Lafayette, Ind., only about 20 miles from where I had found them the previous year, I captured *Isosoma grande*, and on the following day found them present in the wheat fields.

During the fall of 1885 I took the precaution to sow a small plat of wheat and so protect it that no insects could reach it. The cover was renewed in spring, and some of the *Isosoma tritici* emerging from straws taken from the field the previous summer were placed in the inclosure where the young protected wheat plants were growing. The adults were placed on this young wheat April 12, and the utmost care taken to prevent any other insects from reaching them,

[a] The records and material in the files and collections of the State Laboratory of Natural History show that what is probably the larvæ of this species was found in abundance in wheat straw in the fields in southern Illinois, in July, 1884, and adults of the summer form (*grande*) were collected by Mr. Garman, at that time an assistant of Dr. Forbes, in various localities in southern Illinois, during late May and early June, 1884, or just about the time that I began to observe it about Oxford, Ind.

and, besides, the fields were closely watched for *Isosoma grande*. On June 2, fifty-one days after, I found a female of *Isosoma grande* in the inclosure and in the act of ovipositing in the now full-grown wheat plants. Others were observed similarly engaged during the following fortnight, and when the straw was ripened it was cut off and placed in glass jars. I had thus again reared the one supposed species from the other. During the following winter many adults were reared from these straws, but all were of the one form (*I. tritici* Riley), and I had reared the two forms twice from each other, leaving now no further doubt that they were simply two generations of the same insect, besides showing that as the spring generation is without wings and can not fly from one field to another, a simple rotation of crop on the part of farmers would result in keeping the insect so reduced in numbers as to place it out of necessary consideration as a wheat-destroying insect.

In all of my own rearings of both forms of this species I did not secure a single male, and of the large number reared at the Department of Agriculture at Washington, from material furnished by me, but three individuals of this sex were obtained.[a]

RILEY'S NAME, ISOSOMA TRITICI, INVALID.

In a more recent study of these insects,[b] Dr. L. O. Howard found that the species described by Dr. Fitch as *Isosoma tritici* was a valid one. This being the case, Riley's name must no longer be used, and the later one, *Isosoma grande*, thus covers both. Doctor Howard has given the name *minutum* to the wingless spring form, and this name will hereafter be used in this paper.

LIFE HISTORY.

The insect passes the winter in the center of the straw, just above the joint, in the pupal stage. Rarely an adult will emerge in late autumn, but if kept indoors others will appear during December, the most during January, showing that they are ready to appear during the first settled warm weather in spring. In further proof of this, I have found that as the winter advances they require less time indoors in which to develop than if the straws are brought in in December, thus showing that, while subject to all of the influences of winter, they are undergoing a change that carries them nearer to maturity. With the settled spring weather they eat a round hole in the straw and make their way forth. As males are few they rarely pair, if at all, but are ready to begin oviposition as soon as out of the straw. They

[a] Report U. S. Comm. Agr. 1886, p. 573, footnote.

[b] Grass and Grain Joint-worm Flies and their Allies, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr.

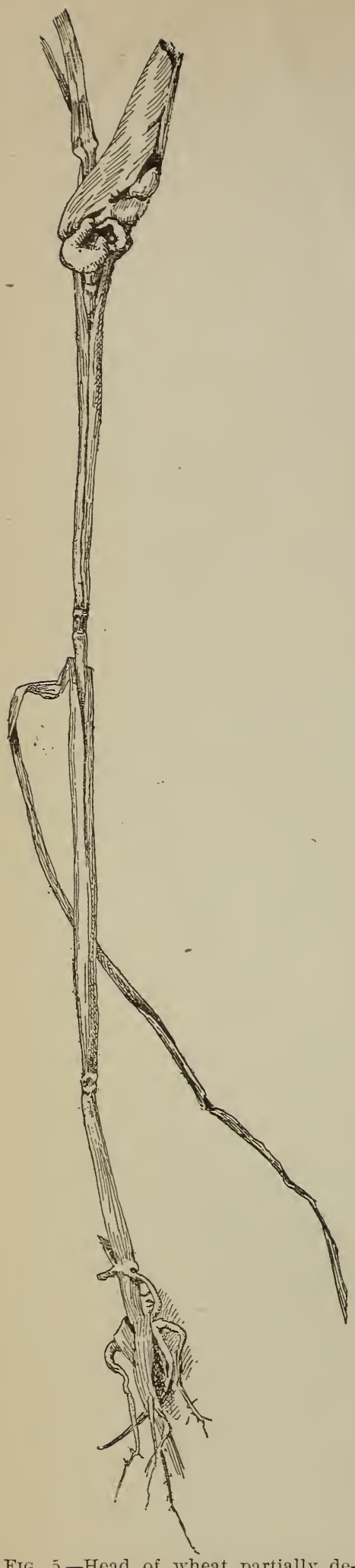

FIG. 5.—Head of wheat partially destroyed by *Isosoma minutum* (drawn in Division of Entomology).

are, except in rare cases, entirely devoid of wings, and migration is therefore out of the question, except for short distances.

OVIPOSITION OF THE SPRING FORM (MINUTUM).

At the time that the minute, wingless females that comprise this form appear in spring the young wheat plants are only starting to throw the stem upward, and if one will take the trouble to cut one of them directly through the center, longitudinally, he will be able to observe the embryo head not far above the surface of the ground. Pushing its ovipositor through the stem to the center, the mother insect places her egg in the embryo head, which is not only the most vital part of the plant, so far as the fruitfulness thereof is concerned, but where her offspring will be in the midst of the most tender and highly nutritious food possible. As a result of this the young head is destroyed and further growth of the stem prevented. In some instances the young larva is itself destroyed before it has finished its destruction of the head, and a distorted wheat head supported by a dwarfed and weakly stem is the consequence. One of these partly destroyed heads is illustrated in fig. 5. In most cases the stem ceases to grow, withers up, and dies, though usually standing upright, at the height of from 1 to 6 inches, with the leaves drooping down about the stem, both dead and discolored. In feeding on the young head the larva forms a cell-like cavity which, owing to the size of the larva and pupa, sometimes takes on a somewhat gall-like appearance, not noticeable except when cut in two. It would seem that the superior article of food which nature provides for these larvæ might to some extent account for the larger and more robust adults which constitute the second or summer brood. The larvæ must develop quite rapidly, as,

by June 10, nearly all have transformed to the adult summer form (*grande*), which begins to appear about June 1, reaching its maximum in point of numbers about June 20, though I have found an occasional individual as late as the 27th of that month. In ovipositing, *minutum* seems to prefer the lateral stems in which to place her eggs, thus leaving the central stem unaffected. With the summer form (*grande*) this selection is reversed and the largest and most thrifty stems are selected. Spots of rank growing, thinly placed grain will suffer worse than the more densely growing areas.

OVIPOSITION OF THE SUMMER FORM (GRANDE).

Nurtured in the midst of the embryo head, we would naturally look for an adult insect differing somewhat from the one developing from larvæ whose food is of a coarser and tougher nature, and in this case, whether as a coincidence or otherwise, we have a much larger insect with fully developed wings, forming in consequence the migratory brood of the species. That these females wander about from field to field is shown by the fact that they may be captured during June by sweeping over the grass lands with an ordinary insect net, such as is used by entomologists for this purpose.

The method of oviposition between the spring and summer forms does not differ materially, except as the difference in the conditions of the plant makes slight variations necessary. The former must place her eggs in the very young plant comparatively close to the surface of the ground, while the latter seems to try to get her egg immediately above the uppermost joint of the wheat stem within her reach. At the season of the year when this takes place the upper, and frequently the joint next below, is not uncovered by the leaves and sheath, but the majority of the eggs are placed, singly, just above either the second or third joint below the head, and rarely above the upper joint. The significance of this to the farmer is that very few of the larvæ hatching from these eggs will be taken away with the straw, but, on the contrary, left in the field in the stubble. If the reverse were the case, and most of the larvæ removed with the straw to the barnyard, there to be either run through the stables or similarly utilized, in most cases hardly an individual would get back into the wheat fields in spring, for it must be remembered that at this period the adults are wingless and incapable of flying. The method of oviposition is shown in fig. 6, *a*, and the point where the egg is deposited in the straw is shown in figure 6, *b*, the transverse line showing the track of the ovipositor. To place her egg, the female takes up her position just above the joint, with her head downward. She then straightens her legs, thus throwing her body away from the stem, at the same time bringing her feet almost directly beneath the body. She now brings the abdomen downward and forward between her legs, much

as a bee would do if alighting and instantly stinging an animal. The next move is to let the tip of the abdomen strike the stem and then go back to its proper position, but the tip of the ovipositor does not; on the contrary, it catches on the surface of the stem, directly beneath the body of the insect, and by putting its machinery in motion and drawing the stem toward her she slowly forces the ovipositor into the soft, juicy stem at the point where this is solid and not hollow, as is the case a short distance above and immediately below the joint. The tip of the ovipositor is composed of two flattened plates arranged side by side, the edges of which are sharp, and are propelled with a sort of rotary motion alternating with each other. In this way the ovipositor cuts and drills its way to the center of the stem, and an egg is forced down the interior and left in its proper place in the stem of the plant. The female recovers her ovipositor by again straightening her legs and pushing the plant from her. Only one egg is placed in the same location, though perhaps more than one is placed in the same straw by the same female, but if so they are placed above different joints in the straw. The larvæ must mature quickly, for, though pupation does not take place until about October, the stem ripens and becomes tough and woody, wholly unfit for the food of the larvæ, within less than a month. It would seem that the mother insect is aware of this, as she invariably selects the greenest and rankest growing plants in the more open spots, where the straw matures the slowest and remains green and juicy the longest.

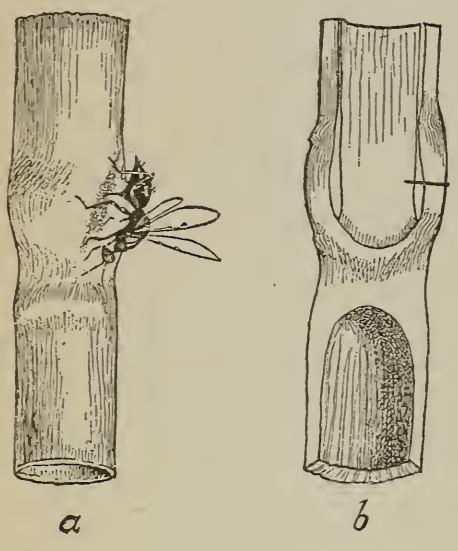

FIG. 6.—Method of oviposition of female of summer form (*Isosoma grande*, Riley): *a*, female inserting her eggs; *b*, section of wheat stem showing point reached by oviposition (after Riley).

Briefly, then, the insect passes the winter in the stubble—with the exception of the few that have been removed with the straw—in the pupal stage. In late March or during April the spring form (*minutum*), small, jet-black, ant-like, and with rare exceptions wingless females, eat their way out of their winter home and seek the young growing wheat plants. They deposit their eggs singly, placing them in the embryo head. These hatch within a few days and the larvæ mature and transform to the form *grande*, large, robust, also jet-black, with fully developed wings, in late May and the first two-thirds of June. These last are also females, and without pairing they begin to deposit their eggs in the now nearly fully developed straws. The eggs are placed just above the uppermost joint accessible to the female, usually the second or third below the head. But a single egg is deposited in a place, the object of the mother insect seeming to be to get it in the center of the stem in the more or less solid portion

just above the joint. The eggs, as with those of the spring brood, hatch in a short time, and the larvæ reach maturity by the time the straw has become too tough and dry to afford further nutriment. The larva at this time usually gnaws its way down into, or at least partly into, the joint, and without forming cell or cocoon, about October passes into the pupal stage.

DESCRIPTION.

ADULTS OF SUMMER FORM.

(*Isosoma grande* Riley.)

Length of body, 4.2 mm.; expanse, 7.6 mm. Antennæ rather more slender and less clavate than in the spring form and but half the length of the thorax. Thorax with the mesonotum slightly more rugulose; wings larger and less hyaline than in the winged specimens of the spring form, with the veins extending to the outer third, the submarginal nearly four times as long as the marginal; legs with the femora less swollen. Abdomen not so long as the thorax, stouter than in the spring form, ovate-acuminate, approaching typical Eurytoma. Less hairy than in the spring form, especially about the legs, the hairs about the abdomen being less numerous, less regular, and shorter. Coloration similar to that of the spring form, but brighter and more highly contrasting, the promotal spot larger and brighter yellow, the pedicel of the antennæ yellow, and the femora with a definitely limited suboval yellowish spot below, near the tip, extending two-fifths the length of the femur on front pair, smaller on middle pair, and still shorter and less definite on posterior pair.

Larva greenish yellow in color. Average length, 6 mm.; otherwise of same proportions and structure as in spring form.[a]

Pupa, average length, 5 mm. Except in larger size and ample wingpads undistinguishable from that of the spring form, *minutum*.

Egg of the ordinary ovoid form with pedicel about twice as long as the bulbous part. The apical end is furnished with a distinct hook, perhaps for the purpose of holding the egg in place while the ovipositor is being withdrawn from the plant.

ADULTS OF SPRING FORM.

(*Isosoma minutum.*)

Length of body, 2.8 mm.; expanse of wings, 4 mm.; greatest width of front wing, 0.7 mm.; antennæ, subclavate, three-fourths the length of thorax; whole body (with exception of metanotum, which is finely punctulate) highly polished and sparsely covered with long hairs toward the end of abdomen; abdomen longer than thorax and stouter. Color, pitchy black; scape of antennæ, occasionally a small patch on the cheek, mesoscutum, femoro-tibial articulations, coxæ above and tarsi (except last joint) tawny; pronotal spot large, oval, and pale yellowish in color; wing veins dusky yellow and extending to beyond middle of wing; submarginal three times as long as marginal; postmarginal very slightly shorter than marginal, and stigmal also shorter than marginal. (See Riley, Am. Nat., 1882, p. 247.)

Larva, length, 4.5 mm.; of the shape indicated in fig. 3; color pale yellow; mouth parts brownish. Antennæ appearing as short two-jointed tubercles. Mandibles with two teeth. Venter furnished with a double longitudinal row of stout bristles, a pair to each joint. Each joint bears also, laterally, a short bristle. Stigma pale, circular; ten pairs, one on each of joints 2 (mesothoracic) to 11.

Pupa, jet black without other coloring; smaller than that of summer form. That is to say, the pupæ wintering over in the straw and from which the spring form develops is thus to be described; that following the larvæ developing in spring is understood to belong to the summer form.

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[a] Riley, Ann. Rept. U. S. Dept. Agr., 1884, p. 58.

NATURAL ENEMIES.

Probably the most efficient enemy of this species is a small, slender, four-winged fly, of somewhat brilliant metallic-colored body and yellow legs. This has a very slight resemblance to an Isosoma, and, indeed, was described as *Isosoma allynii*, now known as *Eupelmus allynii* French. A somewhat similar insect with metallic body and yellow abdomen, *Stictonotus isosomatis* Riley, is very efficient in destroying the larvæ in the straw. *Homoporus* (*Semiotellus*) *chalcidephagus* Walsh and beyond a doubt other chalcids are also instrumental in holding it in check. These parasites are all the more efficient as they are double-brooded also, developing in late summer and at once ovipositing in other larvæ. There is also an egg parasite that I have reared in connection with Isosoma, but not with certainty from this species. This is *Oligosita americana* Ashmead MS. As in all cases where I have obtained this there were species involved other than the one under consideration, it is obviously impossible to say that it destroys the eggs of this species, but with such regularity does it occur in connection with Isosoma in general that no doubt it preys upon this one with the others. When the wheat is harvested the straw is frequently, and, in fact, almost invariably, cut off between joints, thus leaving the larvæ, if there are such in the straws at that point, exposed to attack from predaceous insects. The larvæ of a small, slender, black and yellow carabid beetle (*Leptotrachelus dorsalis* Fab.) crawls up, descends into the stubble and devours the Isosoma larvæ, but unfortunately its taste seems to be too obtuse to allow it to confine itself strictly to Isosoma, and as a consequence it devours parasites as well as host. The mite *Pediculoides* (*Heteropus*) *ventricosus* (fig. 7) is also an enemy, gaining access to the larvæ precisely as with the beetle larvæ previously mentioned.

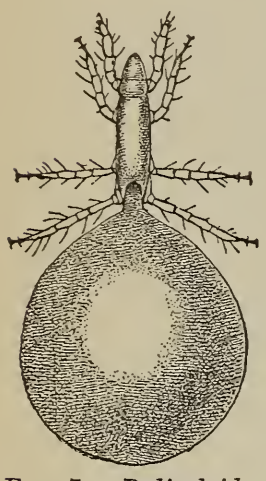

FIG. 7.—*Pediculoides ventricosus* Newp., a mite which destroys the larva—much enlarged (after Marlatt).

PREVENTIVE AND REMEDIAL MEASURES.

The fact of the spring brood being almost entirely wingless and therefore unable to fly from field to field places it almost totally at the mercy of the farmer, as he has but to change his crop from one field to another to rid himself of its presence. It is true the summer form can fly about from field to field at will, and it does so, but if the spring brood of adults are left helpless in a field with no wheat plants in which to place their eggs, it will be seen at once that there can be no summer brood emanating from this source. Rotation of crop will as a consequence be sufficient to prevent an overabundance of this species. But there are conditions under which this is not practicable, as in some

sections and with some farms the soil is but little fitted for other crops, and where wheat follows wheat year after year for an indefinite period. Under such conditions, burning the stubble before preparing the ground for the new crop in fall will prove effective. If this burning is delayed until September, many of the parasites will have developed and escaped. The burning can be best carried out by cutting the grain as high as possible, leaving the stubble long. A few days before burning a mower should be run over the field, cutting off all grass and weeds, which, when dried, will add to the fuel supplied by the stubble. Taking advantage of a favorable wind, the farmer can burn over his field cleanly, thereby not only ridding it of the presence of this pest, but also the Hessian fly, besides burning up much of the seed of foul weeds and grasses.

DISTRIBUTION.

This species seems to occur throughout the middle belt of country from the Atlantic to the Pacific, wherever wheat is grown as a staple crop. Whether it is single-brooded in the North and is, therefore, in such countries capable of sustaining itself in spring wheat, is not yet known. Having no other known food plant than wheat, it will necessarily follow that its range will be restricted to areas of wheat cultivation, and being double brooded, requires fall wheat in which to develop. The fact of its having been so long confused with what now seems the true joint-worm fly (*Isosoma tritici* Fitch) renders its actual distribution, as well as the extent of its ravages in the past, somewhat obscure. I found the summer form (*grande*) in considerable numbers in spring wheat at Lafayette, Ind., June 19, 1895, and it is likely that it can breed therein, though fall wheat is necessary for form *minutum*.

THE JOINT-WORM.

(*Isosoma tritici* Fitch. Figs. 8 and 9.)

I have previously referred to the confusion of *Isosoma tritici* Fitch with *I. hordei* Harris, and which was so persistently insisted upon by Walsh and Riley. It was not until 1896 that Dr. Howard succeeded in establishing the fact that this is a valid species, and now we are confronted with a long series of complications that can only be safely corrected by carefully rearing both species and studying them anew. Failing entirely in securing sufficient material from wheat in carrying out the investigations upon which this bulletin is based, I feel now very much like letting the insect alone until an opportunity is offered to untangle the knotted skein. Doctor Fitch stated distinctly that the term "joint-worm" was to be applied to the insect attacking wheat, and it was because of the mistake of considering it the same insect as that described by Harris that the name "joint-worm" came to be applied to *I. hordei* at all; a mistake that belongs neither to Harris nor Fitch, but one that has misled nearly everybody.

PREVIOUS RECORD OF THE INSECT.

About the year 1848, in central Virginia, throughout the country adjacent to Charlottesville, Albemarle County, and Gordonsville, Orange County, the wheat began to suffer seriously from attack of what was at that time called the joint-worm. In 1851 the wheat in Albemarle County was, much of it, not worth the harvesting. In 1854 the ravages of the pest had become so serious that a "joint-worm convention" was held in Warrenton to devise means for controlling it and preventing, if possible, its further ravages, as by this time it had become almost impossible to raise wheat at all in the infested territory. The action of this convention was to recommend a better system of cultivation, the use of guano and other fertilizers to promote the rapid growth and early ripening of the grain, and the burning of the stubble after harvest.

FIG. 8.—*Isosoma tritici* Fitch: adult of the joint-worm, much enlarged (from Howard).

Looking back to this period, our later-day entomologists can hardly understand how there should have been any difficulty in determining beyond a possible doubt the author of all of this destruction. Doctor Fitch, who, it seems, received some of the growing wheat plants infested with the larvæ from that locality, always insisted that he found a cecidomyian larvæ inhabiting cells like those occupied by the joint-worm and that these were the true depredator, and, though he continued to stoutly defend his determination, we have yet to discover a Cecidomyia either causing or inhabiting such a cell or gall in the wheat plant. From all that has been since learned relative to these insects it is clear that the ravages were those of this species, with, perhaps, individuals of the preceding species intermixed among them. As a matter of history it may be stated that Doctor Fitch was still unconvinced that the joint-worm, and not a dipterous insect, was responsible for the dam-

age in Virginia as so late as 1859 he expressed astonishment that he was unable to rear any Hessian flies from the same straw from which he reared the joint-worm. Surely the unentomological farmer might be pardoned for falling into the same error until, at least, he is placed in possession of some way of distinguishing them from each other.

After finding out beyond question that this is a valid species, that it is the true joint-worm fly attacking wheat and not barley, while *Isosoma hordei* attacks barley and not wheat, notwithstanding the effect on the straw is much the same, and that though it resembles *Isosoma grande* rather closely, it is quite different in habits and life history, we are forced to conclude that we really know very little about it. I have reared it in limited numbers from wheat straw in Illinois, Indiana, and Ohio, though it would appear that about 1885 it became excessively abundant in some parts of Michigan, and, in fact, I am not sure but that I have myself found the larvæ in some abundance, but supposed them to belong to the preceding species. The uncertainty in regard to the identity of these larvæ was owing to the fact that at the time they were observed this was not considered a valid species, and I at that time considered them as belonging to *Isosoma grande*, but now doubt my former opinion from the fact that this species does not always form galls either in wheat or Elymus, that there were several larvæ between the joints instead of one, and that they were located just under the inner walls of the straw, but not forming a cell, whereas those of the species last considered is found only in the center of the straw, in the more solid substance, immediately above the joint

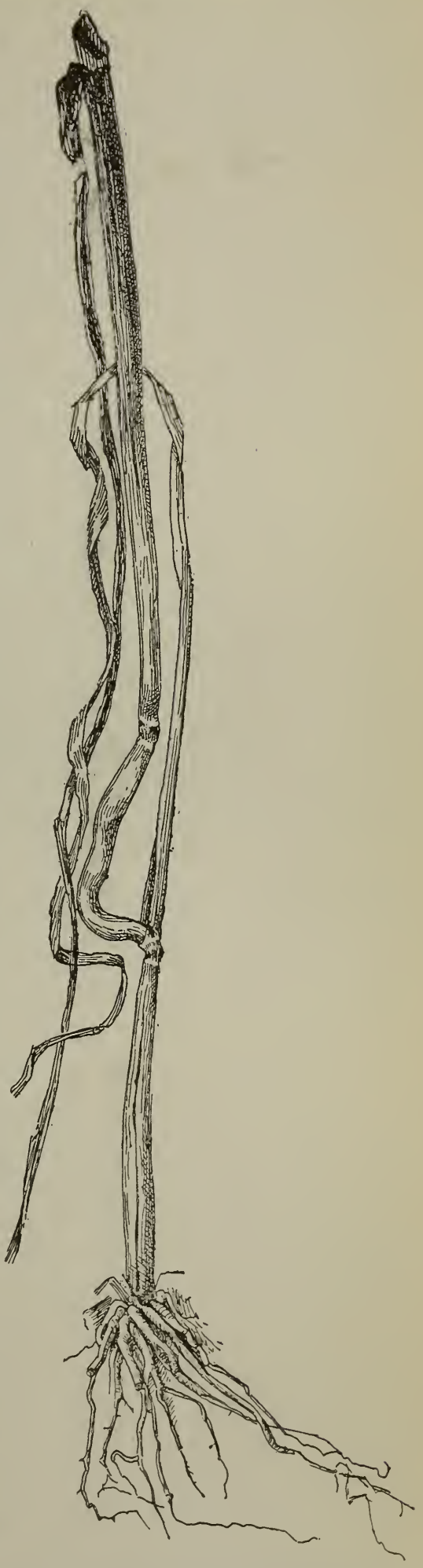

FIG. 9.—Effect of joint-worm in wheat straw (drawn in Division of Entomology).

itself. In 1885 Professor Cook described *Isosoma nigrum*, which he states was reared from larvæ forming creases and hardened deformities in the straw. Professor Cook's specimens, sent to Washington, have been determined by Doctor Howard as *Isosoma tritici* Fitch.[a] (See also Walsh, Trans. Ill. St. Agl. Soc., vol. 5, pp. 485–490, figs.)

LIFE HISTORY.

The larvæ pass the winter in the straw, if in wheat, and in the stems of Virginia rye grass (*Elymus virginicus*) in the East, and *E. glaucus* and another grass, either *Bromus ciliatus* or a species of Agropyron, in California.

In the Middle West the adults appear the latter part of May and early June. The egg does not differ materially from that of *I. grande*, and it is probable that the method of oviposition is much the same as in that species, the female placing her eggs in the young growing wheat plant just above the uppermost joint to which she can secure access at the time. Ordinarily the upper joint is not yet uncovered, except in case of very early wheat, and in that which has made less advance even the second joint from the head is so covered with the sheaths that the insect is unable to determine its position, so that sometimes we find more larvæ between the second and third joints than we do farther up between the first and second, precisely as with *I. grande*. The larvæ reach their full growth by harvest, but do not pupate until the following spring.

All adults are winged, and both sexes are represented. Outside the wheat field I have reared the insect only from *Elymus virginicus*, and I question its breeding in the stems of cheat (*Bromus secalinus*) for the reason that I have reared it from the rye grass and not from the cheat, though both were abundant in the same locality. Mr. Koebele, who reared it from *Elymus glaucus* in California, was uncertain whether he also reared it from *Bromus ciliatus* or Agropyron. Both the Bromus mentioned by Koebele and *Agropyron repens* occur in the East, and it is very probable that future studies of the species will show that there are other grasses besides rye grass that will require attention from the farmer who wishes to guard against its appearance in his fields by preventing its breeding permanently along roadsides and the borders of his fields.

DISTRIBUTION.

Doctor Fitch received this insect from Maryland, Doctor Lintner and Professor Comstock reared it in New York, the United States Department of Agriculture has it from Virginia and North Carolina, Professor Cook reared it in Michigan, I have reared it in Ohio and Illinois

[a] Grass and Joint-worm Flies and their Allies, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., p. 18.

and found it in Indiana, Doctor Fletcher has reared it in Ontario, Canada, and Mr. Koebele in California, and there is hardly a doubt that investigations will reveal its presence throughout the entire wheat-growing region of North America. Being fully winged and single brooded, as well as capable of breeding in abundance outside of the grain fields, there seems no good reason why it should not cover the whole country, attacking either spring or winter wheat.

DESCRIPTION.

"*Female.*—Length 4 mm.; expanse 7.6 mm. Head, pronotum, and mesonotum strongly rugulose but not umbilicate-punctate except toward tip of scutellum, where an occasional umbilicate puncture occurs; metanotum also strongly rugulose, with a faint trace anteriorly of a median longitudinal furrow; metanotal spiracles large and perfectly circular; pronotal spots moderately large and often faint, but plainly discernible from above, sometimes, however, quite bright and distinct. Abdomen longer than thorax, nearly as long as head and thorax together; abdominal segments 4 and 5 together longer than 2, 3 only about half as long as 4, and 5 as long as two preceding united; first funicle joint one-half longer than second; club longer than three preceding funicle joints together. Body slightly but plainly pilose except at sides of metanotum, where the fimbria is very obvious. Legs black except at joints, which, with the tarsi, are yellow. Claw of stigmal club given off before the tip.

Male.—Length, 2.9 mm.; expanse, 6 mm. Petiole shorter than hind coxæ, faintly punctate; flagellum of antennæ uniformly pilose, joints well rounded above, not strongly pedicellate; joint 1 three times as long as wide and nearly three times as long as pedicel; none of the funicle joints constricted in the middle; joints 2 and 3 each nearly as long as 1; joints 4 and 5 each a little shorter; club plainly divided by a distinct incision into two joints, but the terminal ovate joint is not pedicellate." Howard, Tech. Ser. 2, Div. Ent., U. S. Dep. Agr., pp. 17, 18.

Originally described by Fitch, Jour. N. Y. State Agr. Soc., 1859, p. 115. Cited as *Isosoma hordei* by Walsh, Amer. Ent. and Bot., II, p. 332. Described as *Decatoma basilaris* by Provancher, Faun. Ent. Can., II, p. 569.

NATURAL ENEMIES.

The natural enemies are, with few exceptions, probably the same as with the preceding species, to which this is more closely related than with the one that follows, at least so far as its life history is concerned. In my own rearings I have invariably bred this in connection with *I. grande* if from wheat straw, or with *I. elymi* if from grass, so that personally I am not able to say that certain parasites actually came from *I. tritici*, though there is no reason for doubting that such was the case. Certain parasites do most certainly confine themselves to particular species of Isosoma. *Websterellus tritici* Ashm. has only been reared from this species, as it is now known. An undescribed Isosoma occurs in considerable abundance in the stems of *Tricuspis seslerioides*, and from this I have reared a parasite belonging to the genus Torymus, but strangely enough this parasite has only been

reared from this particular Isosoma, even where the grass infested by its particular host was growing in the midst of Elymus, literally alive with the larvæ of three other species of Isosoma. Thus, while some parasites attack all of the species, there are evidently others that restrict themselves to one.

REMEDIAL AND PREVENTIVE MEASURES.

Owing to its possessing wings whereby it is capable of flying readily from one field to another, or breeding in the stems of grasses in the intervening territory, a rotation of crop will be less effective in the case of this species than with the preceding. For the same reason, careful attention to roadsides, borders of fields, and ditches becomes all the more imperative. The burning over of the stubble fields before preparing the ground for wheat again in the fall, or the same treatment of the uncultivated areas above mentioned at any time during winter or early spring will effectually exterminate these insects where these measures are carried out. In the Middle West wheat seldom follows wheat on the same ground for a series of years, the grain being rotated with red clover, which prevents the burning over of the stubble fields in the fall, but does not in any way affect the treatment of grass lands, and if the crop is rotated annually and the borders and waste places attended to there is little likelihood of the farmer suffering greatly from the depredations of this insect. I have invariably found the most serious injuries to occur on thin or poorly fertilized soils or where the land had not been thoroughly prepared before seeding. Probably whatever tends to produce a healthy, vigorous growth of the wheat plant will tend to discourage oviposition by the insect. It is not known that the insect prefers one variety of wheat to another, but the variety with the stoutest straw will probably suffer least from attack.

DIFFICULTY IN RECOGNIZING THE SPECIES.

I have made no attempt to describe the larva and pupa in their proper place, because I do not believe they can be separated by any description from those of the preceding species if in wheat, or those of *Isosoma elymi* French if in grass. Notwithstanding this the farmer can readily separate them at the proper season of the year, even if both are present in his cultivated fields. After October this species will be in the form of a yellowish white larva in the stubble, while the preceding species will be in the form of a black pupa, both perhaps in the center of the stubble. In spring the larvæ of this species will change to a jet black pupa, while those of *I. grande* will have developed and escaped. So, then, pupæ found in the fall will probably belong to the preceding species; those found in spring, if in wheat, to this, and larvæ found after October, if in wheat stubble, also to this species. However,

too much reliance must not be placed on these distinctions, as there are other supposed species of these insects attacking wheat of whose larvæ and pupæ we know nothing, but with our present knowledge the facts just given are the best that can now be offered the farmer in order to enable him to separate the different main enemies of his grain and receive whatever practical benefit is possible from what information is now available, leaving future studies to throw more light upon his problems. The adults can be easily separated from those of the preceding species by their smaller size, and from the next by their smaller size and the color of the legs, which in *I. hordei* are honey yellow. The larvæ are also smaller than those of the following species and may or may not cause galls and deformities in the straw. The adults of the summer form of the preceding and those of the following species are abroad at the same time as are those of this species during the last days of May and early June.

While fig. 9 illustrates the effect of the larvæ on a wheat plant, there are so many variations from this that it is at present impossible to separate these two gall-forming species by their effect on the straw.

THE BARLEY STRAW-WORM.

(*Isosoma hordei* Harris. Fig. 10.)

Up to 1896 this species was confused with the preceding and the term "joint-worm" applied thereto. The fact is, Harris seems not to have given this name to his species at all, but on the other hand Doctor Fitch applied it to his *I. tritici*, and it was owing to the confusion of these two insects that the name became misapplied, and I have here given Harris's species the name "barley straw-worm," in accordance with the name *hordei*.

PREVIOUS RECORDS OF THE INSECT.

Of all of our described species of Isosoma this was the earliest known and was for many years supposed to be the only species infesting cultivated grains or, in fact, inhabiting this country, as it was considered a parasite on the real depredator, presumed to be some kind of a two-winged fly, and was actually described by Dr. W. T. Harris in 1830 as a parasite, under the name *Ichneumon hordei*.[a] Doctor Harris certainly seems to have been aware of the fact that as early as 1821 Mr. James Worth, of Sharon, Bucks County, Pa., found larvæ clearly belonging to some species of Isosoma affecting the culms of wheat "near the root, where they caused enlargements of the stem;"[b] and in 1823, Mr. Joseph E. Muse, of Cambridge (Eastern Shore), Md., reared an insect, also from wheat, which he termed a

[a] New England Farmer, July 23, 1830; Ins. Mass., 1841, pp. 434–437.

[b] American Farmer, vol. 4, p. 394.

"Tenthredo," whose larvæ, as he stated, "burrow within the stems and feed upon them."[a] Doctor Harris, in the edition of 1841 of his Insects of Massachusetts, page 434, refers to the statement of Dr. Andrew Nichols, of Danvers, who stated that worms found in his barley straw were about one-tenth of an inch in length and of a yellow or straw color, and that in the month of November they appeared to have passed into the chrysalis state, but living through winter unchanged in the straw. The insects referred to by Mr. Worth, of Pennsylvania, and Mr. Muse, of Maryland, might quite probably have been *Isosoma tritici* Fitch, but if the one referred to by Doctor Nichols was an Isosoma at all it was certainly *I. grande*, as that is the only species attacking grain that is known to pupate in the fall. Thus it will be seen that it is not easy to determine just what Harris might have included as belonging to his *I. hordei*, though he nowhere states that it was ever obtained from any other than barley straw; hence the name, *hordei*, applied to it. It is interesting to know that specimens labeled in his handwriting "Parasitic in barley, June 15, 1830," are still in the museum of the Boston Society of Natural History, so that there can be no mistake in the identity of the insect described. Even in the edition of his Insects of Massachusetts, of 1841, Harris makes no mention of his species having been found affecting wheat. In the edition of 1852 he relates that about eight years before children sleeping on straw beds in Cambridge, Mass., had been bitten by these insects and the annoyance had been so great that the beds, both straw and ticks, had been burned. Now people do not use barley straw for such domestic purposes, nor in fact do they use wheat straw as a rule, but oat straw. As Doctor Harris does not enlighten us as to what kind of straw it was from which the insects annoying the children came, we still have no direct proof that this species was ever known in connection with wheat straw.

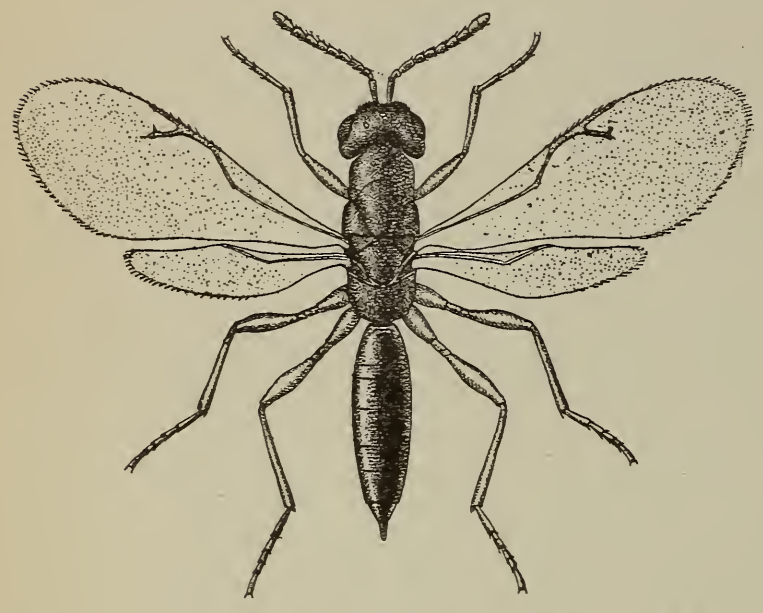

FIG. 10.—*Isosoma hordei* Harris: adult of the barley straw-worm (from Howard).

About 1852 there appeared a similar trouble in the barley in central New York, and though Doctor Fitch described it as a distinct species under the name *Eurytoma fulvipes*,[b] we now know that it was

[a] Loc. cit., vol. 5, p. 113.

[b] Jour. N. Y. Agricultural Soc., Vol. IX, p. 115.

Isosoma hordei. This last outbreak in central New York appears to have been rather widespread and disastrous, for in 1858 Hon. George Geddes, president of the State Agricultural Society, stated that while formerly a yield of 40 bushels of barley to the acre was expected, they could not at that time rely upon more than 20, and unless relief came barley growing, on account of the attack of this pest, would have to be abandoned.[a]

There was a local outbreak of this species in Ontario, Canada, in 1867–68, and observed at Wakeman, Chagrin Falls, and Barry, Ohio; Indiantown, Cuckoo, and Paynes, Va.; Albany, N. Y.; Canada West (William Couper); Ottawa, Canada; and Urbana, Carbondale, and Marshall, Ill. So far it has not been reported from the Pacific coast States. Doctor Fitch confined this species to the insect reared by Harris in Massachusetts, and the one working the injuries in central New York as *Isosoma fulvipes*, both of which are now known to belong to *Isosoma hordei.*

LIFE HISTORY

The species is single brooded. The adults of both sexes, all fully winged, emerge from the straw and grass in late May and early June, ovipositing almost immediately. The effect of the larvæ on the growing plants begins to show within a short time, and, though the larvæ become full grown during June and early July, they remain in this condition within their cells until May of the following year.

EFFECT OF THE LARVÆ ON THE PLANT.

The eggs may be deposited in the stem of barley or grass anywhere between the root and the head, even among the lower spikelets of the head. The effect of the larvæ may be to cause hard, woody cells, whose outline is indicated only by slight discolorations, the outer surface of the stem being smooth and not in the least swollen, the cell being entirely within the walls of the stem, causing no distortion in the straw; or there may be anywhere from one to a dozen galls in a cluster, and these may be either clearly defined or so packed together and cramped as to lose all semblance to the typical galls and take on the appearance of diminutive growths, resembling the black knot of the cherry and plum. The straw or grass stem may be enlarged to two or three times its natural size, forming an elongated oval woody growth that pushes its way outward, bursting, as it were, the sheath at base, and showing between the edges. This growth is usually on one side of the stem, just above the joint, and is marked with interlacing creases and furrows indicating the outlines of each individual cell, and in many cases sending downward from the lower extremity small root-like appendages, the use or cause of which it is difficult

[a] Trans. N. Y. Agl. Soc., 1859, p. 332.

to understand. All of these malformations as well as others may be found in the stems of *Elymus canadensis* in abundance, from which swarms of the adults will emerge in late May and early June. Owing to the woody nature of these abnormal growths, straw attacked by this species is more likely to be broken up into small bits, and these go in with the grain at thrashing, thereby increasing the danger of transportation from one locality to another, but to offset that, as it were, there is likely to be a greater proportion of the insects left in the stubble than with the other species, as the affected straws are usually more stunted in growth and shorter. At present there is no other insect attacking wheat, rye, or barley that causes similar growths in the straw except *Isosoma tritici* Fitch, in wheat, and the farmer can hardly mistake the work of these two pests for those of any other in his fields.

DESCRIPTION.

"*Female.*—Length, 3.6 mm.; expanse, 6 mm. Pronotum and mesonotum minutely but strongly rugulose, smoother than *I. tritici*; metanotum more coarsely rugulose, the larger elevations taking a longitudinal direction, no central furrow or carina; pronotal spot very small, not visible from above. Abdomen as long as head and thorax together; joints 4, 6, and 7 subequal in length, the fifth a little longer; joint 3 a little longer than 4, 2 hardly longer than 3 and 4 united; funicle joints 2 to 5 submoniliform, but still a little longer than broad. All legs (except coxæ) and antennæ honey-yellow, flagellum and femora a little darker; claw of stigmal club straight, given off well before tip of club; pilosity sparse.

"*Male.*—The only males which I have seen are the two from the Harris collection. These are both in very bad condition; neither had an abdomen and one has no antennæ. With the other, but three funicle joints remain on the left antenna (the others being broken off) and four on the right, but the latter are still inclosed in the pupal sheath. The three funicle joints remaining on the left antenna are not pedicellate, very slightly arched above, and furnished with close, moderately short hair not arranged in whorls; joint 1 longest, 2 and 3 successively decreasing. Joint 4 is still shorter, judging from the sheathed right antenna." (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., pp. 18, 19.)

The foregoing description was drawn up from specimens in the Fitch collection, labeled, in Fitch's handwriting, "*Eurytoma fulvipes* Fh.;" other specimens from the Harris collection, reared from barley, June 15, 1830; other specimens from "Canada West," and still others reared by myself from stems of *Elymus canadensis* growing near Champaign, Ill. This is the *Ichneumon hordei* described by Harris in the New England Farmer, the *Eurytoma fulvipes* described by Fitch in his seventh report, and the *Isosoma hordei* mentioned by Walsh in the American Entomologist (Vol. II, p. 330).

The larva, except from its larger size and habit of living within a cell, is not distinguishable from that of the other species of grain-infesting Isosoma. It is little larger than that of *I. grande*, found in May and early June, and it has the universal yellowish-white color. The same may be said of the pupa.

NATURAL ENEMIES.

The larvæ appear to suffer more from the inroads of natural enemies than do those of other species of these insects, perhaps because of their inhabiting the walls instead of the center of the straws, thereby rendering them more accessible. It may be that this is the older form, and a greater number of the parasitic species have become adapted to it as a host insect. There is little doubt that *Oligosita americana* Ashm. and *Polyneura citripes* Ashm. both attack and destroy the eggs, as I have reared them in numbers from stems of Elymus inhabited by the larvæ, and also the stems of other grasses inhabited by other Isosoma larvæ. *Eupelmus allynii* French, easily known by its slender body, metallic color, with yellow legs, is associated with this as it is with nearly all other species of these insects that inhabit the stems of grain and grass. *Merisus isosomatis* Riley, conspicuous for its yellow body, is almost as abundant as the preceding, and, as the name implies, is parasitic on other species also. *Homoporus chalcidephagus* Walsh is also a parasite, but I have reared it in lesser numbers than the other two, in Illinois, Indiana, and Ohio. Almost the first parasitic species that I reared in connection with the present studies of *Isosoma hordei* was a second new genus and species, *Parapteromalus isosomatis* Ashmead MS. I have myself witnessed the oviposition of all of these parasitic species, and their life history is probably practically the same. The adults emerge in spring a little later than those of the Isosoma, but there is a second generation of adults in summer, and it is these that I have observed placing their eggs in the cells of *I. hordei*, thus doubling their effectiveness in holding it in restraint and preventing more frequent and greater devastations in the grain fields of the farmer. While carrying on the present investigation I have reared an undetermined Eurytoma, a parasite on Isosoma, but as I reared four species of the latter from the same lot of stems, it is impossible to say to what extent it preys upon the one now under consideration, nor do I know anything in connection with its habits, except that it makes its appearance in spring, simultaneously with other parasites.

PREVENTIVE MEASURES.

The preventive measures might well be summed up under the caption of good farming, for there is not one practical measure but will pay for its carrying out, aside from its entomological influences. As the adults are fully winged and can fly freely from one field to another, less must be expected from a rotation of crop, but even under these conditions, a certain amount of benefit will result from a careful system of crop rotation. Wheat, rye, or barley should never be grown on the same land for more than two years in succession without carefully burning over the stubble before preparing the

ground for another seeding. To these must be added the mowing off of roadsides and along fences and margins of fields during late June or early July, or the burning over of these during winter or early spring, thus destroying the hibernating larvæ. The rye grass along the margins of fields and ditches should receive special attention in the matter of mowing and burning. It is not known whether or not anything is to be gained by early sowing, which, besides, is apt to invite the attack of Hessian fly.

THE CAPTIVE ISOSOMA.

(*Isosoma captivum* Howard. Fig. 11.)

Very little is known of the habits and transformations of this species. I found it in a field of growing rye near Normal, Ill., May 10, 1884, and swept it from timothy and bluegrass about Lafayette, Ind., during May, 1885, and again during the same month in 1886. Dr. J. A. Lintner reared both sexes from wheat straw sent him from Johnsons Creek, Niagara County, N. Y., in December, 1887, the adults appear-

FIG. 11.—*Isosoma captivum* How.: adult (from Howard).

ing in March of the following year, the straw having, presumably, been kept indoors during the winter.[a] Probably the adults occur normally at about the same time as those of *Isosoma hordei*, *tritici*, and *elymi*. We know that it attacks wheat, probably rye, and perhaps barley.

DESCRIPTION.

"*Female.*—Length, 3.4 mm.; expanse, 5.8 mm. Head and mesonotum uniformly, finely, and closely rugulose, not shagreened; metanotum more coarsely rugulose and with a narrow and shallow central longitudinal groove, which widens slightly posteriorly; pronotal spot plain, moderately large; hind coxæ delicately punctate.

[a] Fourth Report, State Entomologist of New York, p. 34.

Abdomen shiny, as long as thorax, oblong-ovoid; the second segment occupying nearly one-third the whole surface; segments 4 to 6 subequal, the third a little shorter; funicle joints 2 to 5 subequal; club nearly as long as three preceding joints; joint 1 one-half longer than 2; pile sparse and short, more marked at metanotal fimbria and terminal joints of abdomen than elsewhere. Color uniform black, except for pronotal spot, tarsi, middle and hind femoro-tibial knees, front tibæ and apical third of front femora, which are light honey yellow. Stigmal club about as in *I. hageni* and *I. agrostidis*, except that its tip is more rounded instead of squarely truncate.

"*Male.*—Length, 2.5 mm.; expanse, 5 mm. Punctation rather finer than with female; petiole as long as first abdominal joint, strongly rugose; flagellum of antennæ long; pedicel not globose, slightly elongate; joint 1 of funicle longest, twice as long as pedicel; joints 2, 3, 4, and 5 each a little shorter than its preceding joint; not so strongly pedicellate as with *I. californicum* and *I. bromi*, moderately arched above with hairs arranged in two indefinite whorls; club separated into two subequal pedicellate joints, giving the funicle the appearance of being 6-jointed instead of 5-jointed, as with *bromi* and *californicum;* scape short, about as long as pedicel and first funicle joint together; strongly expanded below tip. Coloration like that of the female." (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., pp. 13, 14, 1896.)

The earlier stages of development are unknown, but they probably differ little from those of allied species. Quite likely the same natural enemies prey upon it and the same repressive measure will apply to it as with the preceding species.

WEBSTER'S ISOSOMA.

(*Isosoma websteri* Howard. Fig. 12.)

This is in all probability a wheat-infesting species, as I found it in a wheat field near Bloomington, Ill., May 9 and 11, 1884, and about Lafayette, Ind., also in fields of wheat, June 2 and 16, 1885. I also

FIG. 12.—*Isosoma websteri:* adult female—much enlarged (from Howard).

reared it from a pupa taken from a growing wheat plant in the Bloomington, Ill., field May 29, but have not encountered it since in my studies of these insects. Nothing is known of its life history

except what I have just given. Its close resemblance to *I. maculatum*, which I have reared from stems of cheat from the vicinity of Champaign and Urbana, Ill., is quite suggestive, the adults of this last species being abroad during late May and early June in the same localities.

DESCRIPTION.

"*Female.*—Length, 3.4 mm.; expanse 6.3 mm. Head, pronotum and mesonotum as with *I. maculatum;* metanotum with only the beginning of a central furrow, its lateral carinæ immediately curving around the sides, each inclosing an oval, flattened, nearly smooth portion of the metascutellum; a median carina extending nearly to the tip of the sclerite; pronotal spot moderately large and plainly seen from above, occupying a little more than one-third of the dorsal aspect of the pronotal foreborder. Abdomen much longer than the thorax; segments 3 to 5 increasing in length; 6 and 7 as long as 5. Antennæ with joint 1 of the funicle twice as long as 2; joints 3, 4, and 5 gradually decreasing in length, subequal in width; joint 5 more closely connected with club than with the preceding joint. Color and wing venation as with *I. maculatum.*" (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., pp. 15, 16, 1896.)

While, as stated, this is probably a wheat-infesting species, it is to be remembered that it has been reared only in a single instance, and it is within the range of possibility that my growing wheat plant, as I supposed, might possibly have been cheat, as it is easy to confuse the young plants, and as the two grow everywhere intermixed in the fields mere collecting offers no solution of the problem whatever. Of the four species of *Isosoma* which I have reared from common cheat (*Bromus secalinus*), viz, *I. elymi*, *I. albomaculata*, *I. hirtifrons*, and *I. maculatum*, none were found in the wheat straws growing in the same field.

Should the species become numerous enough to cause serious depredation it will probably yield to the same repressive measures as the other grain-attacking forms.

THE HAIRY-FACED ISOSOMA.

(*Isosoma hirtifrons* Howard. Fig. 13.)

The type specimens of this species were reared from rye straws collected by Mr. Coquillett, in Mercer County, Cal., in 1885. It was reared by myself from stems of common cheat growing in a wheat field near Urbana, Ill., in 1902. I know nothing whatever of its life history except that it appeared in my breeding cages in common with the other cheat-infesting species. The records of the Illinois State Laboratory of Natural History and those of the office of the State entomologist contain numerous references to Isosoma attacking rye.

Specimens of the affected straws show that a part of this injury was due to *Isosoma tritici*, whose presence could be detected by the larval cells in the walls of the straw; also many straws were attacked by a noncell-making species, the larvæ being in the center of the stems immediately above the joint. No adults were reared, as the larvæ were supposed to be those of the old *Isosoma tritici* Riley, which is not now known to attack any grain except wheat. It is therefore impossible to say which of the species whose larvæ live in the center of the stem it was that did the injury in these cases. I made every effort to secure material from the fields of rye about Urbana and Champaign, Ill., during the summer of 1902, but was unable to find any infested straw, and therefore can throw no light upon the identity of the rye-attacking species; but the fact that the one under consideration is known to affect rye in California would place it under

FIG. 13.—*Isosoma hirtifrons* How.: adult female, much enlarged (after Howard).

suspicion wherever it occurs in the eastern States. I judge that it will be very easily confused with other species, and the fact of its infesting cheat would lead to the suspicion that it will be found infesting other grasses.

DESCRIPTION.

"*Female.*—Length, 3.7 mm.; expanse, 7 mm. Sculpturing of head, pronotum, and mesonotum as in *I. websteri*, except that there are sparse, large, shallow punctures on the mesoscutellum; cheeks much fuller than in other species; metanotum as with *I. maculatum*. Abdomen about as long as thorax; segments 3 to 6 increasing in length. Antennæ stout, moderately long, very hairy; proportions about as in *I. websteri*. Body not unusually pilose, except face, which is closely covered with short white pile; pronotal spots very plain, but not large, occupying about one-third of the dorsal aspect of the fore-border of the pronotum. Color black, except for all femoro-tibial knees and pronotal spot. Claw of stigmal club given off some distance from tip, delicate and short." (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., p. 16, 1896.)

Up to the present time cheat has been looked upon only as an undesirable plant growing among wheat like weeds among corn, but it now appears to be doubly undesirable on account of its harboring insect enemies of cultivated grains.

ISOSOMA SECALE Fitch.

This was described by Doctor Fitch in 1861, after he had become fully convinced that these insects were not parasitic but the true depredators among grain.[a] I have not myself encountered it in the study of grain insects, but from the statements of Doctor Fitch it does not seem to differ in habits from *Isosoma hordei* and *I. tritici*, and one can not help suspecting that a careful study of its life history and development will show that it is one of these species. It was given the common name of "rye fly," and adults were reared from straws grown in 1860, emerging about the 1st of June, 1861. The larvæ were found to occupy cells in the walls of the rye straw, and not in the base of the sheaths, as was supposed to be the case with *I. hordei*, though Doctor Fitch describes "the disease which the insect causes in the rye being in every particular like that in barley and wheat." As we now know, barley and wheat are attacked by two different species, but all three seem to have precisely the same life history, so that whether there be one species or more, the farmer will be able to meet it or them with the same preventive measures.

DESCRIPTION.

"*Female.*—Length, 3.6 mm.; expanse, 6.6 mm. Punctation as with *I. hordei;* pronotal spot large, plainly seen from above. Abdomen as long as head and thorax; segments 4 and 5 subequal; 6 and 7 together shorter than 5; 2 much longer than 4 and 5 together. Color black; scape and legs black; front tibiæ, knees, and tips of middle and hind tibiæ and all tarsi honey yellow; claw of stigmal club given off near tip of club, somewhat curved; antennæ as in *I. hordei.*

"*Male.*—Length, 3 mm.; expanse, 5 mm. Specimen in poor condition. Expansion of scape more abrupt from tip than with other males described; funicle joints well arched above, scarcely pedicellate, each with 2 indefinite whorls of hair and with no median constriction; each joint twice as long as wide; club plainly divided into two joints, but no trace of pedicel to terminal joint, resembling *I. hordei* in this respect; petiole a little shorter than hind coxæ and shorter than first abdominal segment." (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., p. 19, 1896.)

In this connection it may not be out of place to state that I have reared an undetermined species of Isosoma in connection with *I. hordei* from the stems of *Elymus canadensis*, growing near Champaign, Ill., and seeming to affect the grass much in the same manner as

[a] Seventh Report Noxious and other Insects of New York, pp. 849–851.

that species. It may on further study prove to have some connection with the one now being discussed, though I have not found it attacking rye.

FITCH'S ISOSOMA.

(*Isosoma fitchii* Howard.)

This is the last of the described Isosomas known to attack growing grain, though I have reared what appears to be still another from wheat straws from Carbondale, Ill.; but the specimens are still undetermined and nothing definite can now be said of them. This species was described from 2 females and 1 male found in the Fitch collection, labeled in Fitch's handwriting, "*Eurytoma hordei* Harris, Nos. 15223 and 15197." Nothing whatever is known of its habits, but it was presumably reared, with some other species, from grain.

DESCRIPTION.

"*Female.*—Length, 3 mm.; expanse, 5.8 mm. Head, pronotum, and mesonotum faintly shagreened, nearly smooth, shining; mesoscutellum with a few sparse punctures; metanotum with a complete median longitudinal furrow emarginate on the anterior half and with a central carina extending nearly to tip; very coarsely rugulose either side of the furrow with a faint granulation between raised lines; pronotal spot large, plainly seen from above, and two spots together occupying about one-third of the dorsal aspect of the foreborder of the pronotum. Antennæ with well-separated joints; funicle joints 2, 3, 4, and 5 equal in length and width; joint 1 a little longer; joint 5 as well separated from the club as from preceding joint; club a little longer than 4 and 5 together, but of the same width. Abdomen as long as the thorax; joint 4 shorter than 6; 5 longer than 6; 7 and 8 subequal. Color black, except for pronotal spot and knees, which are luteous; claw of stigmal club given off about at tip of club, straight.

"*Male.*—Length, 2.2 mm.; expanse, 4.2 mm. Petiole about as long as hind coxæ and nearly equal in length to first abdominal segment. Antennæ with funicle joints very slightly arched above, each joint fully three times as long as wide, and slightly constricted in the middle; otherwise as with *I. hordei.*" (Howard, Tech. Ser. 2, Div. Ent., U. S. Dept. Agr., p. 20, 1896.)

I have now treated all of the species of these insects known to attack cultivated grains in this country, though there may be still others as yet unknown. These known species have been described in each case, not especially for the benefit of the unentomological farmer, but because this publication will go to many lands and into the hands of many different peoples. Some will care nothing for descriptive matter, and such can easily pass over it in the use of this bulletin, but there will be others who will look to its pages for aid in determining with exactness the identity of the species which they may have before them, and for these descriptions are a necessity. Some of the species included may appear to be of no especial interest to the practical farmer, but of this no one can confidently predict. It may be true to-day and not

true to-morrow, for no one can tell what year or in what part of the country any one of these, even the one that seems the most insignificant, may suddenly come to the front and commit serious depredations over a considerable area. Besides this, they are all of them so obscure in appearance and their effect on the plants they attack so subtile and hidden from the eyes of the farmer that he is unaware of his loss until on threshing his grain he finds that it does not turn out well and the kernels are light and shriveled. It is like the thefts of a trusted official—they are not missed until, by accident, perhaps, the defalcations are discovered, when we are struck with amazement at their magnitude and ask ourselves and each other how it is possible for such things to go on continually through a long series of years and escape detection. The financial loss occasioned by an unusually disastrous outbreak of these pests can be estimated, but it is a mistake to suppose that such losses constitute more than a very small percentage of the amount annually filched from the farmers by these insidious foes of his crops. It is not so much the big losses that occur at rare intervals, and of which we read much in the public press, but the infinite and perpetual leaks from this source that pull down the farmer's profits—leaks that, as has been shown, he may readily prevent in a most inexpensive manner. It is for the very reason of their obscurity and insidious attacks, coupled with the magnitude of the losses caused by them through a long series of years, that has prompted a study of their habits and the publication of the facts in the present form.

THE TWO-WINGED GRAIN AND GRASS FLIES.

The insects included under this head are true flies, having only two wings and their young are maggots without feet, eyes, or jaws. They belong to the family Oscinidæ, containing a large number of species with variable food habits, some of them not attacking plants, but living on the cast skins of other insects, shells of insect eggs, and in the burrows made in plants by other insects. Some of them are leaf-miners, others live in galls on grasses, while still others live underground on the roots of plants. Still others, that are known to live in the stems of grain and cause more or less destruction by their attacks, will be here considered, though it must not be supposed that there are not still others of such depredators of which we as yet know nothing.

Our grain-affecting species are to be found in the genera Meromyza, Chlorops, Elachiptera, and Oscinis. It is to the last that the very destructive frit-fly (*Oscinis frit*) of England and Europe belongs and which is so terribly destructive to grain crops in those countries. The habits of *Meromyza americana* have been pretty well studied and we now have a fairly good knowledge of its life history and habits; but of the most of the other species belonging to the above genera we only

know that they attack the stems of wheat and other smaller grains, but we are far from possessing a full knowledge of their life cycles. *Chlorops proxima* Say is known to attack wheat plants in Kentucky, flies emerging in May; I have reared *Elachiptera longula* Loew from maggots in the stems of *Panicum crus-galli* in Illinois, the flies in this case appearing late in August, and from both wheat and oat plants in Indiana. It has also been reared from oats in Ohio by Prof. W. B. Alwood. From wheat plants in Indiana I have reared *Elachiptera nigricornis* Loew, and from the same lot of plants I reared also *E. costata* Loew, the latter having been reared from oats in Ohio by Professor Alwood and from maggots found in a decayed cavity in the roots of living garden radish in Illinois by Mr. Coquillett. The extent to which the larvæ of the last species attacks and destroys wheat plants is uncertain, for though I have reared them from volunteer wheat plants growing up in the fields I have never been able to separate their maggots from those of Oscinis. I have reared *Oscinis trigramma* Loew and *O. coxendix* Fitch from volunteer wheat plants in Indiana, and *O. dorsata* Loew, *O. coxendix* Fitch, *O. umbrosa* Loew, and *O. trigramma* Loew from August-sown wheat at Wooster, Ohio. *Oscinis carbonaria* Loew is treated in this paper under the head of the lesser wheat-stem maggot. The larvæ of all of these except Meromyza closely resemble each other, work in the young plants, and, some of them at least, destroy the central stem before the plant tillers or individual tillers afterwards. The larvæ or maggots are small, yellowish white, pointed anteriorly, but more blunt at posterior extremity, without jaws, but provided with a pair of minute hooks whereby they rend the tender growth of the plant and extract the juices. They may generally be found in the midst of their work surrounded by the injured tissue and grass saturated with the sap of the plant, and later on the brown puparia may be observed about the bases of the young plants in late fall and even outside the sheaths, and scattered on the ground in spring. They are often mistaken by farmers for the "flaxseed" or corresponding stage of the Hessian fly.

WERE PROBABLY ORIGINALLY GRASS FEEDERS.

Beyond a doubt the larvæ of these flies were originally grass feeding, and we find them at present developing in the stems of grass, but seemingly preferring grain at times, probably when the grain at the time of oviposition offers a more inviting place for the female to deposit her eggs with the assurance that her offspring will be within reach of an ample supply of food. Until the last half of the last century the average farmer paid little attention to such matters, and, as the flies were as now less thoroughly studied than other insects, there was little to encourage the entomologist in attempting to study their habits, as it is rather a thankless task to rear them and get their life

history worked out only to learn that the species can not be determined, and the information thus gained is thus rendered practically worthless because of not being able to state definitely which of the many forms one has been studying. Only recently I have learned the name of a species reared from grass stems eighteen years ago. For this reason even now the earlier stages of nearly all of those reared from growing grain are obscure or unknown, the flies having simply been reared from grain or grass, but the young of any particular species can not be separated from those of perhaps a half dozen other similar flies. There is much need at present of careful studies of these insects with a view of determining their exact relation to agriculture, and especially to what extent they may be combated outside the grain fields of the farmer. At present not more than one farmer out of a thousand knows of their existence, and the injury they do is attributed to the Hessian fly, thus to a certain degree throwing obscurity over all reports of the ravages of the latter insect, which can not be reached outside the grain field, while some at least of these other flies surely can. When I began to study the life history of the lesser wheat-stem maggot, in 1884, it was the most unsatisfactory and, at that time, to all appearances, the most unprofitable piece of work that I ever undertook, for the reason that it was impossible to separate it from other similar species; but this has now been largely overcome with this insect, and we know that much can be done to prevent its injuries.

EARLY REPORTS OF INJURIES TO GRAIN.

One of the earliest reports of injuries to grain in this country that can be attributed to these insects with any degree of certainty was cited by A. S. Fuller, from the works of M. Du Hamel du Menceau (New Hamburg edition of 1759), as follows:

> There is a smaller kind of worm which gets into the roots, chiefly oats, and working upward destroys all the inside of the plant, which perishes soon after. I suspect it to have been an insect of this kind that destroyed so much wheat in the neighborhood of Geneva, and which M. de Chateauvieux described thus: "Our wheat in the month of May, 1755, sustained a loss which even that cultivated according to the new husbandry did not escape. We found in it many little white worms, which afterwards became a chestnut color. They post themselves between the blades and eat the stems. They are usually found between the first joint and the roots. Every stalk which they attacked grew no more, but became yellow and withered. The same misfortune happened to us in the year 1732. These insects appeared about the middle of May and made such havoc that the crop was almost destroyed."

The attack on oats was clearly that of the stalk borer or heart worm, the caterpillar of the moth *Papaipema* (*Gortyna*) *nitela* Guen., but that in the wheat does not accord with the work of any other than of some of these small grain and grass flies under consideration. Mero-

myza maggots do not turn brown or "chestnut colored," and those of the Hessian fly, even if it were known to occur in America at that early date, do not eat off the stems. As early as 1822 Mr. James Worth, of Bucks County, Pa., seems to have reared these flies from maggots attacking wheat.

It is therefore probable that as the area of cultivation increased in this country these insects have gradually transferred their attention from grass to grain as a matter of necessity, and though more or less numerous every year in the grain fields, they become excessively so when the grass conditions are less favorable than those of the grain; but the grasses are a continual source of supply from which the grain fields are colonized. These interrelations may be more or less curtailed by the farmer with but little expense.

THE GREATER WHEAT STEM-MAGGOT.

(*Meromyza americana* Fitch. Fig. 14.)

PAST HISTORY OF THE INSECT.

This is in all probability an insect native to the far South, as it occurs in Mexico and northward over the entire United States and far into British America, its food plants, before the advent of the Caucasian farmer, being the wild grasses. The fly was described in 1856 under the name here applied, but without definite proof of its attacking grain further than that it was collected in wheat fields and closely resembled the European species *Meromyza saltatrix* Linn. There is now, however, considerable evidence of its having attacked growing wheat at least as early as 1822 in Pennsylvania[a] and in 1845 in Michigan.[b] The evidence furnished by Mr. James Worth, of Bucks County, Pa., indicates that three broods were observed, as he calls attention to the attacks of "a little worm found in the lower part of the stalks of wheat and rye in spring and fall and about the joints in June." Of these larvæ he says that "some were pale yellow, with brown spots about the mouth," which would imply that they were those of some species of Isosoma; but he further states that one kind was found in volunteer wheat, which the Isosomas do not attack, and their larvæ are not found in the plants in fall, and in case of only one, with a possibility of another species, are they to be found in the plants in spring. While Mr. Worth evidently was not able to separate the different species of the larvæ found in growing grain, his careful descriptions and exactness in locality and dates are exceedingly valuable and enable those familiar with the forms of which he writes to recognize them with reasonable clearness. Hence we are left with little doubt that he observed the larvæ of Isosoma and Meromyza

[a] The American Farmer, vol. 4, p. 394; Memoirs Penn. Agl. Soc., Vol. I, p. 165.
[b] Prairie Farmer, Sept., 1845, p. 216.

without separating them, and also in fall, including those found in volunteer wheat, this latter species and other Oscinidæ. The reference in the Prairie Farmer seems to have been drawn out by a notice in the Michigan Farmer of a new wheat insect in that State, described as the product of a greenish fly about three-sixteenths of an inch in length, whose larva is a white worm one-fourth of an inch long, ribbed, without feet, with two forked lines on its forehead, found in the straw above the upper joint, where it devours the juices which would otherwise ascend to the head, but which denote the presence of the worm in the straw by turning white prematurely when the grain is in the milk. There is also here reference to the presence of "9 eggs * * * found in a single straw, one of which had just hatched," but which eggs, so called, are now known to have been the bodies of a minute parasitic mite, whose rounded form is not unlike that of an egg and which is occasionally found attacking the maggot in the straws.

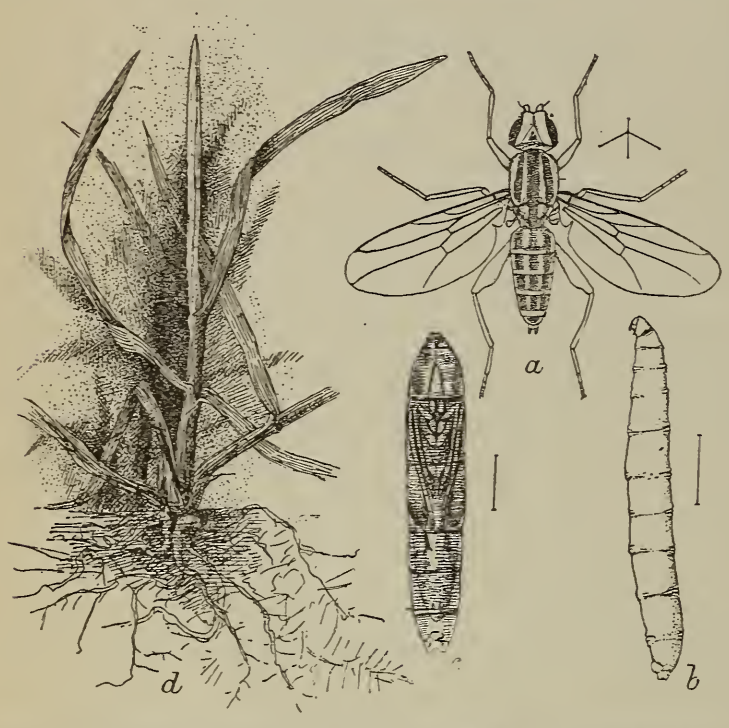

FIG. 14.—Greater wheat stem-maggot (*Meromyza americana*): *a*, mature fly; *b*, larva; *c*, puparium; *d*, infested wheat stem—all enlarged except *d* (from Marlatt).

Doctor Fitch did not rear the flies which he described, but collected this in connection with several species of Oscinis by sweeping in the wheat fields with an insect net. Being familiar with the grain attacking habits of similar insects in Europe, he expected, as he says, to rear the flies from the growing wheat plants at different seasons, but failing, as he states, to do this, contented himself with describing the flies without attempting to connect them with the injuries which he clearly observed. Nothing further appears to have transpired relative to this insect until in the year 1867, when Doctor Riley reared the fly from larvæ working in the growing stems of wheat, immediately above the upper joint, in the month of June, and in Missouri. In this case the flies appeared during the first week of July, after a pupal period of twelve to fourteen days. These facts were published in the Rural New Yorker for January 28, 1869, and in his first report as State entomologist of Missouri he discussed the insect and gave illustrations of the adult, larval, and pupal stages, but does not appear to have suspected the occurrence of a second brood later in the season. In 1876 a farmer of Hinckley, Ohio, reported it as attacking his spring wheat.[a] We

[a] Country Gentleman, July 27, 1879.

also hear of it during this same year in the State of New York, where stalks of growing wheat containing the larvæ were sent to Doctor Lintner, from Scipioville, in August. Some of these stalks contained larvæ, and some of the flies were observed crawling about on the table where the package had been unwrapped, and these were supposed to have emerged from the straws while in transit. Doctor Lintner adds nothing to our knowledge of the species at this time, but gave it the common name of the wheat stem-maggot in preference to Doctor Fitch's American Meromyza.[a]

In March, 1883, Dr. S. A. Forbes, State entomologist of Illinois, received information of serious injuries to young wheat in Fulton County, of that State, and on investigation found the depredator to be a small, slender maggot which attacked the plant just above the root, thereby killing it. Farmers in the infested territory had noticed the injury during the preceding November and December, but had not taken steps to learn of its destructive character until, with the coming of spring, the pest seemed to break out anew. From larvæ taken from infested plants from these fields puparia were obtained April 30, and the flies began to appear by May 4, and continued to emerge until June 1, thus showing that the insect might do serious damage to young wheat in the fall, pass the winter in the maggot stage, and resume its work of destruction again in spring. This, taken in connection with what had been observed by Riley and Lintner, showed plainly that the flies emerging in May and June oviposited in the growing stems of the wheat, and the larvæ hatching from these eggs entered the stems just above the upper joint. Doctor Forbes, in his thirteenth report as State entomologist, gave full details of his observations and called attention to the possibility of a third brood developing in midsummer, and also gave the insect the common name of the "wheat-bulb worm."[b]

During the summer of 1884 I was engaged as a special agent of the Division of Entomology, under Doctor Riley, and from June 1 to October was located at Oxford, Ind., engaged in the study of grain insects, especially those attacking wheat. From straws taken from a field near Oxford I reared adult flies up to July 26, and volunteer wheat, taken from this same field September 5 and sent to Washington, gave adults September 11, 13, and 16, according to the divisional notes. During the same year adults were reared from volunteer wheat October 1 and found in the field of young wheat on October 6.[c] In 1886 Doctor Forbes put the final touch, so to speak, to the settlement of the occurrence of this midsummer brood by finding both eggs and larvæ on August 4 in volunteer wheat, and in his fifteenth report (p. 39) constructed a calendar showing the periods covered by the several broods.

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[a] Loc. cit., Vol. XLIV, p. 535, 1879.

[b] 13th Rept. State Entomologist of Illinois, pp. 13–29, 1884.

[c] Rept. U. S. Comm. Agr., 1884, p. 390; Bull. 9, Purdue Univ., Oct., 1886.

This calendar shows our combined work on the insect, and is all the more valuable on account of our having worked entirely independently of each other over territory within the same latitude, and with other conditions in every way similar. It is also a matter of interest that on February 27, 1891, I collected all stages of the insect except the eggs in wheat growing on the grounds of the Agricultural College of Texas, at College Station.

LIFE HISTORY.

Throughout the region of latitude 40° N. the insect is three-brooded, although there may be but two in the north and more than three in the far south, though Doctor Fletcher states that about Ottawa, Canada, about latitude 45° N., there are three broods, the adults appearing in the beginning of June, the end of July, and again late in September. My observation in Texas, about latitude 30° 30′, does not necessarily indicate additional broods, as there may be, as with the Hessian fly, a prolonged summer resting period, during which the insect is continued in a stage requiring no food and incapable of reproduction, until the vegetation upon which the larvæ are dependent for their food supply begins to take on new life, and, as with the Hessian fly, we may find that the very conditions that serve to prevent the starting up of the fresh growth of vegetation, so essential to the life of the young larvæ, has also the effect of retarding the emerging of the parent insects. Such problems as these are for National investigation, where imaginary lines and political boundaries do not enter into consideration. Within the wheat belt of the United States, broadly speaking, the life cycle of this insect is as follows: The winter is passed in the larval stage, and the short pupal stage coming in May brings the emerging of the adults at the time when the female is able to place her eggs on the plants where the young, on hatching, will make their way to the tender and succulent stem just above the upper joint. By the time the straw has ripened the larvæ have ceased to require food, and pass through the pupal stage, the adults of this brood appearing in July. Eggs are now deposited in volunteer wheat and grass, and, owing either to the retarding effects of meteorological influences or a diversity of food of the larvæ or both, perhaps, the emerging of the adults is prolonged throughout a period extending from late August through September until late October. At this period the fall wheat offers a decidedly inviting plant to the female fly on which to place her eggs with a prospect of her progeny having an abundant food supply. It is the larvæ from eggs deposited during this period that winter over in the plants and give rise to the May-June generation of flies. It is this last brood that is of more especial interest to the farmer, as it is very seldom that the pest does serious injury to grain except in fall and early spring.

DESCRIPTION.

Adult.—Length, 0.17 inch to tip of abdomen and 0.20 inch to end of wings. Color, yellowish white, with a black spot on the top of the head, which is continued backward to the pedicel of the neck. Thorax with three black stripes, approaching each other anteriorly, but not coming in contact, the middle stripe prolonged anteriorly to the pedicel of the neck and posteriorly to the apex of the scutel. Abdomen with three broad, blackish stripes, which are confluent posteriorly and interrupted at each of the sutures. Tips of the feet and veins of the hyaline wings blackish. Eyes, bright green. Antennæ, dusky on their upper side. (Lintner.)

Egg.—Snow white, fusiform, longitudinally ridged, the space between the ridges being concave and marked off into rectangular areas by still slighter ridges transverse to the others. Length, 0.023 inch; breadth, 0.005 inch. (Forbes.)

Larva.—Very pale green, slender, footless, tapering anteriorly, somewhat narrowed, but subtruncate posteriorly; one-fourth of an inch in length by about one-eighth of an inch in width. The segments are thirteen in number, including the head, those in the center of the body being a little wider than long. The four anterior segments narrow rapidly forward, the one next the head being at its apex less than half the diameter of the fourth. The three posterior segments are also somewhat narrowed, the penultimate being about three-fourths the diameter of the second preceding. The head is provided beneath with the pair of black toothed hooks common to many dipterous maggots. The antennæ are very short, scarcely longer than broad, two-jointed, the second joint extensile. There are two circular, apparently sensory, areas below the antennæ upon the front of the head, doubtless representing maxillary palpi. The mouth is beneath the head, sucker-like in form. The last or anal segment is divided into two lobes and bears upon its posterior surface two breathing pores or spiracles, each guarded by a circlet of about twelve depressed spines. The surface of the larva is entirely smooth and shining, except for some very fine transverse ridges on the under side of the segments, evidently used in locomotion. On each side of the base of the second segment is a small, gill-like appendage, divided into two lobes, each lobe with six divisions. (Forbes.)

Pupa.—The pupa of this species is what is technically known as a coarctate pupa, contained within the last skin of the larva, which is not shed previous to transformation, but remains as a protective envelope for the forming pupa. As the latter shows through its case, the color is green, except at the ends, where, with the growth of the pupa within, the case is left empty and transparent. It is about one-sixth of an inch long by one-fifth in width, and divided into ten clearly recognizable segments. The anterior of these, corresponding to the head and first segment of the larva, is yellowish, shrunken, and corrugated, about half the width of the third segment. The second and third are obscurely divided, the first being short and narrowing rapidly forward. Within it are observed the retracted maxillæ of the old larva. The remaining segments to the eighth are about equal in length, separated by deeply impressed sutures at first, the anterior sutures becoming obliterated as the enlargement of the head and thorax of the pupa within distends the envelope. The ninth segment is the longest of all, the tenth being nearly equally long, but narrower, and shrunken and wrinkled on its posterior border. The eleventh, representing the twelfth of the larva, is only a brown and corrugated rudiment. As the development of the pupa approaches completion, the eyes, wing-pads, and legs are visible through the transparent covering, but they form no elevations of the surface. (Forbes.)

FOOD PLANTS.

Besides wheat, rye, oats, and barley, all of which it has long been known to infest, I have reared *Meromyza americana* from the com-

mon bluegrass (*Poa pratensis*), while Doctor Fletcher, in Canada, has reared the flies from maggots in the stems of Agropyron, Deschampsia, Elymus, and Poa, and as he states that the flies are enormously abundant in meadows and prairies all the way from northern Quebec through the Lake Superior region, Manitoba, and the Northwest Territories, there seems to be ample proof of its ability to sustain itself without trouble among the grasses of that country.

The extent to which it attacks fall wheat in autumn is entirely obscured from the fact that, in the majority of cases, it is confused in its work of destruction with the Hessian fly. In Ohio, at a time when the Hessian fly was being accused of devastating whole fields of wheat in the fall, by collecting a great number of the affected plants at the beginning of winter and placing them in the insectary I reared fully as many of these as I did of the Hessian fly, which at that time I was especially engaged in investigating. It is on this account that the entomologist who attempts to study the economics of the Hessian fly, which does not breed in the grasses, will find the greatest difficulty in weighing the evidence offered by those who can not or will not note the difference in the nature of these insects and the great similarity in the final effects of their attacks upon growing fall wheat in autumn and spring.

SELECTION OF FOOD PLANTS BY THE ADULTS.

Either some varieties of the same kind of grain are more or less repugnant to the flies, or else they possess a very finely adjusted sense of the larval preferences for certain other varieties, for they certainly exhibit a considerable discrimination in their selection of the different varieties of wheat on which to place their eggs. Doctor Forbes has called attention to the fact that the most seriously injured fields of wheat in Fulton County, Ill., in 1883, were of the Fultz variety. At Lafayette, Ind., June 14, 1889, among a lot of experiment plats on the experiment-station grounds, sown side by side, on the same day, with the same soil and other conditions, there was a marked difference between the number of affected straws in the Velvet Chaff and in the Michigan Amber, the infestation being fully four times greater in the former than in the latter. Even in the case of larger fields bordering each other the conditions did not vary, and where the two varieties overlapped along the margins the same partiality for the Velvet Chaff had been shown. Doctor Fletcher has also noted a strong prejudice in favor of some varieties of the same kinds of grasses. For instance, while *Poa serotina* was one of the most seriously affected of all of the grasses, *P. pratensis*, *P. cæsia*, and *P. compressa* were almost exempt from attack. Attack on *Setaria viridis* was observed in a single instance.

PLACE AND METHOD OF OVIPOSITION.

According to Forbes, the eggs are placed on the stems of grain, "some being pushed down beneath the ensheathing bases of the leaves and

others cemented to the stems just at the margin of the sheath, while still others were placed along the edge of the sheathing base of the leaf, sometimes being thrust under the edge." This agrees with my own observations and is doubtless the usual method of oviposition, as the main object on the part of the female is to place the eggs where the young larvæ will the most easily reach the tender, juicy stem as soon as possible after escaping from the egg, and is probably true in the case of grasses as well as of grain.

METHOD AND NATURE OF ATTACK.

Both Doctor Lintner and Doctor Forbes have endeavored to indicate this by the selection of explanatory common names for this insect. The former, disregarding Fitch's name, American Meromyza, as too technical, and having observed the larvæ in the full-grown straws only, gave it the name of the "wheat-stem maggot," while Doctor Forbes, having first encountered the larvæ in the bulbous lower stem in early spring, gave it the name of the "wheat-bulb worm," on account of its resemblance to the "wheat-bulb maggot" (*Hylemyia coarctata*) of England. It is really a maggot and affects the stems of the plants which it infests, besides being the largest maggot of this kind at present known to attack the stems of grain in this manner in this country; hence, in order to distinguish it from other smaller stem maggots, I have here termed it the "larger wheat stem-maggot."

The larva has no jaws or mouth, but a couple of hook-shaped appendages by which it tears the plant and feeds from the juices, the cavity made by this destruction of the stem being filled by a pomace-like mass in which the larva is to be found. The effect on the plant is shown by the accompanying illustration (fig. 14, *d*). In young plants the central spindle-shaped enfolded leaf is killed, precisely as with attacks of Oscinis larvæ, the detached portion turning first yellow and later brown, then shriveling up and dying, leaving the outer lower leaves uninjured. In Hessian-fly attacks this spindle-shaped leaf is absorbed and does not appear at all in young wheat in autumn, so that there need never be any confusion of the work of these two insects in fall wheat, and the effect on the full-grown straws is even more easily distinguishable. When attacked by the maggots of this species the fully grown straw withers at the upper joint and all that portion of the stem including the head, the sheath excepted, changes to a whitish color, the remainder of the plant, including the upper sheath, continuing uninjured and of the usual green color. The Hessian fly never affects the full-grown straws in this manner and the lesser wheat stem-maggot does so but rarely, so that the presence of these maggots in the straw can be easily detected shortly prior to harvest by their whitened color from the upper joint upward. The larvæ are within the stem and not outside and under the sheath, as

with the Hessian fly; they are larger and of a more glassy green color than those of the lesser wheat stem-maggot, and it is only when still very young that the ordinary farmer need ever mistake them for any of the others mentioned in this bulletin. It is only in the manner of killing the stem of young wheat that it need be confused with others.

EXTENT OF RAVAGES.

Though present in the fields every year, as is witnessed by the whitened heads of grain in the fields just prior to harvest, I have never known a serious attack at that season of the year; nor is there anything at present to indicate that it is likely to work more serious injury at this season in the future than it has in the past.

Its ravages in the young wheat in fall and spring, as illustrated by the outbreak in Illinois in 1882–83, are not as yet of usual occurrence, though several similar instances have come to my knowledge within the last twenty years. In two cases—one in Indiana in 1888 and another in Ohio in 1900—the fields were also badly infested by Hessian fly, but from the material reared it would seem that this species was to be credited with no small percentage of the loss. Occasionally fields of fall wheat, especially if sown early, are attacked in the fall and ruined by this insect alone, though the damage is in some cases attributed to the Hessian fly. It is, however, easy enough to detect the difference between injuries caused by these insects, as has been explained under methods of attack.

PREVENTIVE MEASURES.

The liability of attack from this insect is not sufficiently great to warrant any expensive measures being put forth in order to forestall possible outbreaks. As yet, we have no way of foretelling these sudden attacks, as the pest has never proven excessively abundant in the same locality two years in succession. The fact that late-sown wheat is less subject to injury, and in cases where the two have been found in a combined attack, the grain has been sown early, indicates that this now-accepted method of warding off an attack of Hessian fly will work equally well with this species. There is nothing at present to indicate any change from these conditions throughout the winter-wheat growing regions of the Northern States. Whether or not the same rule will apply in the South remains to be seen, as we know too little of the pest in that portion of the country to be able to speak positively. In the North, in the regions devoted to the raising of spring wheat, it would appear that a burning over of the grass lands in winter would reduce the probabilities of attack. The destruction of volunteer wheat, which should be done in any case as a protective measure against attacks of Hessian fly, will of course tend to reduce the probability of the young wheat being attacked in autumn. It must be borne in mind,

however, that this is a grass as well as a grain insect, and eradication from the grain fields will not protect from infestation from without.

NATURAL ENEMIES.

The abundance of one of these and the extent to which they are able to perform their deadly work is a most encouraging feature, viewed from the standpoint of the husbandman. A small, shining black, four-winged fly, with reddish-yellow legs (*Cœlinius meromyzæ* Forbes), is exceeding beneficial in its parasitic work on the maggots of this pest. This parasite was discovered and described by Doctor Forbes in connection with the investigations of the outbreak in Illinois in 1883. So abundant is this parasite that it is almost impossible to rear the flies from the straws in July without also rearing numbers of these diminutive friends. They attack the maggots by placing their eggs in their bodies, and the eggs hatching feed upon the maggots and destroy them. This parasite occurs generally with the depredator, even in the far North.

Another natural enemy is the mite *Pediculoides* (*Heteropus*) *ventricosus* Newport, illustrated on page 22. The young of this insect are so very minute as to be quite invisible to the unaided eye. They are without wings, but very active, and make their way to the maggot working within the stem and fastening themselves upon it suck its blood, in the meantime themselves increasing rapidly in size until they appear like minute globular eggs, the abdomen being distended with young, as there are no males, and the body having much the proportions the stem has to the pumpkin. Each female gives birth to a great number of young, which at once either escape to other stems to hunt out their victims or else settle down with the parent. These are frequently found attacking the maggots and are apt to escape detection, or, if observed, mistaken for eggs. The reference in the Prairie Farmer, calling attention to the presence of what probably were these maggots in stems of wheat previously cited, also mentioned the presence of nine eggs with the maggot. Without a doubt these were the mites that had attacked the maggot, though this was long before the mite was known to inhabit this country, it being a native of Europe, as far as now known.

THE LESSER WHEAT STEM-MAGGOT.

(*Oscinis carbonaria* Loew. Fig. 15, *d.*)

With our present knowledge of the early stages of development it is yet impossible for me to separate out from several other allied species such as belong to this one and give a detailed account of its life cycle, and especially is this true with reference to *Oscinis soror*, or what is the same thing, *Oscinis variabilis* Loew. To be able to do this will require the most careful and exact studies of the early stages

of the offspring of adult flies belonging to each species ovipositing on plants known of a certainty to be free from infestation by other species. Such studies can only be carried out with the aid of better conveniences than I have had at my disposal, and should be taken up by the General Government, whose investigators are not restricted by State lines, and who can follow wherever their problems may lead them.

Though *Oscinis soror* (*O. variabilis*) has been reared from growing wheat by others as well as myself, I have found that *O. carbonaria* has been thus obtained with the greatest frequency over the widest range and under conditions that lead to the belief that it is the more important of the two, from an economic point of view at least.

LIFE HISTORY.

This can only be given in a general way, as in no instance has the progeny of a single female been carried through the life cycle and the several broods throughout the year clearly defined. I have myself reared this species from growing wheat in Illinois, Indiana, and Ohio, over not to exceed two degrees of latitude, or collected them in the wheat fields throughout this area, or they have been reared in Washington in the Department insectary from plants sent there by me from this same territory, as follows: Urbana, Ill., July, August, and September; Oxford, Ind., from May to October, not inclusive; Lafayette, Ind., July, August, and September; Wooster, Ohio, May, June, July, August, and September; and in the latter locality from August-sown wheat. In the insectary I have also reared it in November, December, and the following April, but did not observe it abroad in that locality during November, December, or April. Besides these rearings of mine, it was reared at Washington, July 7, from plants received on the 3d of same month from Prof. Lawrence Bruner, West Point, Nebr., and reared by Forbes, in Illinois, September 17, from volunteer wheat. This is the species mentioned by Doctor Fletcher as being so destructive in the Dominion of Canada in 1890, as shown by specimens of the adult which he has kindly sent me.[a]

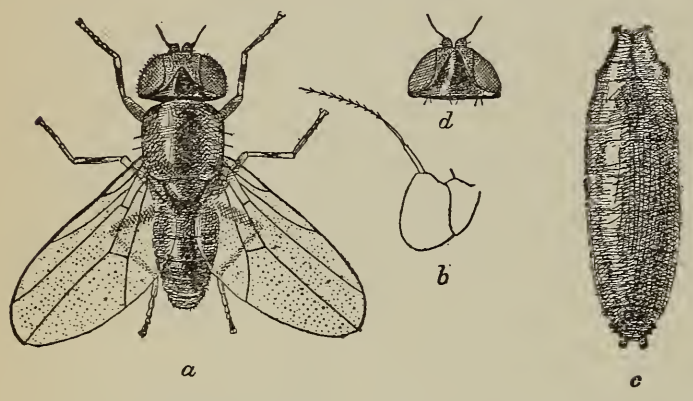

FIG. 15.—*Oscinis soror* Macq.; *a*, mature fly: *b*, antenna of same; *c*, puparium; *d*, head of *O. carbonaria*—*a*, *c*, *d*, magnified; *b*, still more enlarged (original).

There was a bad outbreak of this insect in a field of wheat near Wooster, Ohio, in the fall of 1891, and the field was badly affected. In March of the following year I found many larvæ and pupæ about the bases of the affected plants, and an attempt was made to study

[a] See Experimental Farm Reports, 1890, p. 158, and 1898, p. 177.

them further, but insufficient facilities for doing so prevented. There was, however, plenty of evidence that the insect may winter in either the larval or pupal stages. A single specimen was reared at the Department in Washington from a stalk of wheat received from Mr. J. G. Kingsbury, editor of the Indiana Farmer, the fly appearing June 18. In this case the maggot was in the straw above the upper joint, and the wheat head was evidently killed by its attack. From all of these facts it seems that its life cycle may be about as follows: It may winter over in the field either in the larval or pupal stage, the adults emerging in May. From the presence of larvæ in the stems of wheat and grass from which adults have afterwards been reared it would appear that there is a brood of flies emerging in June and July, much as in *Meromyza americana*, which lay their eggs in grass and volunteer grain; another brood of flies resulting in September and October whose offspring hibernate as previously stated, there being, as in Meromyza, three broods each year, from six weeks to two months being required for the insect to pass through its development during the summer months.

FOOD PLANTS.

I have reared these flies only from wheat, probably because I have made no special effort to rear them from any other plant. Doctor Fletcher has reared the species from *Agropyron caninum*, *A. tenerum*, *A. repens*, *Poa pratensis*, and *Elymus canadensis*.[a]

PLACE AND METHOD OF OVIPOSITION.

I have observed oviposition only among small wheat plants, but presume that the methods employed in such cases do not differ from those where the food plant is some of the grasses. The object on the part of the female seems to be to place her eggs low down on the plant, as near the root as possible and along the enveloping edge of the sheath. The very young larvæ are always to be found in this situation, and the edges of the enveloping bases of the leaves are always ragged and discolored in infested plants.

NATURE OF THE INJURY.

The young maggot on hatching from the egg feeds along the thin edge of the lower base of the enfolding leaf where it is white, juicy, and tender. It seems to make no effort at first to reach the central portion of the plant, seeming to know that that part will remain tender and succulent, but gradually works its way inward and upward to a point just below where the central spindle-shaped unfolding leaf leaves the ensheathing portion of the next older one, the exact locality seeming to be decided upon according to the toughness of this central

[a] Experimental Farms Reports, 1890, p. 158.

leaf, which of course varies with age and may be the first slender shoot of the plant, or one of the older and tougher tillers of much older plants. This central compactly rolled leaf is cut off, the maggot at first working upward until this leaf becomes too tough or begins to wither, when it reverses its position and works downward, where the food supply is always fresh and juicy. Pupation does not take place here, but the larva makes its way when full fed to between the bases of the older leaves, and in that situation the puparia are to be found. A very young plant does not admit of very extended travel by the larva, and in an older one the continuity of its path is soon obliterated by the growth of the plant itself, and the larva is frequently found a couple of inches above the base where it entered after hatching from the egg, as is witnessed by the minute patches eaten out of the leaf. As but a single maggot is found in each stem, I have often wondered if the female so distributed her eggs as to prevent a clashing of young, and feel very much inclined to the opinion expressed in some unpublished notes by Mr. Pergande to the effect that more than one egg may be deposited about a single stem, but the oldest and strongest maggot kills off the weaker, leaving but one in full possession.

EXTENT OF RAVAGES.

Usually the work of this species is so confused with that of others as to render anything like a definite estimate of the damage that can be justly charged to its attacks in the grain fields almost impossible. I have never observed injuries to the full-grown straw, though I have occasionally found larvæ in them that I presumed to belong to this species. In fall wheat the plant recovers from a slight injury, especially if growing in a fertile soil, and I apprehend that more damage will follow an attack in fields where the soil is poor or badly worn than where it is richer. In the field of wheat near Wooster, Ohio, that was so severely injured in 1891, the Hessian fly was also present and did fully as much injury as this insect, both I should say, destroying fully one-half the crop. Dr. Fletcher has called attention to a field of spring wheat in Canada that was damaged fully 75 per cent, for the most part due to the attacks of this species. In the United States, I do not believe that an injury of from 5 to 15 per cent of the crop by reason of the attacks of this and other Oscinis is at all unusual, but this can not in all cases be wholly charged up to this particular species.

DESCRIPTION.

The following description of the fly of *Oscinis carbonaria* has been kindly drawn up for me by Mr. Coquillet:

A small, black, two-winged fly having the knobs of the halteres, the feet, and usually both ends of the tibiæ yellow. Length varying from 1 to nearly 2 milli-

meters (from one twenty-fifth to nearly one-twelfth of an inch). The last joint of the antennæ is nearly circular in outline, and on the upper edge is a nearly bare bristle or arista; on the upper part of the otherwise opaque head is a polished, nearly triangular spot that extends from the extreme vertex almost to the antennæ. The wings are nearly transparent and are without an auxiliary vein—that is, there are only three (instead of four) veins that terminate in the front edge of the wing before its apex; the vein bordering the front edge of the wing extends beyond the extreme apex of the wing; the usual two small cells near the base of the wing are wanting, the anterior one being confluent with the discal or central cell, while the posterior one is wanting, there being only one cell (the axillary) behind the fifth vein. The legs are devoid of bristles and of stout, apical spurs, and are rather short and robust; the first joint of the feet is rather slender and longer than any of the other joints. The thorax is also without bristles, except along the sides and across the posterior end; it is somewhat polished and is devoid of gray dust. The face does not project strongly forward on its lower part; the proboscis is short, robust, and terminates in the fleshy lips.

CLOSE RESEMBLANCE TO OSCINIS SOROR MACQ.

Oscinis soror Macq. is very closely related, but may be distinguished by the fact that the polished spot on the upper part of the head extends only about halfway from the vertex to the antennæ, instead of almost reaching the antennæ, as in the preceding species. (D. W. Coquillett.)

At present, owing to the confusion of this species with *soror*, an account of which will follow, it seems impossible to give desirable descriptions of the preparatory stages of this insect. I have followed those of Professor Garman, not knowing whether he was dealing with this species or not, but because his descriptions seem to me to apply as well to this as any that I could supply. It must be kept in mind, however, that this is only a temporary makeshift to give some kind of an idea of what these look like, and thus enable the farmer to reduce the uncertainty as to the identical species that is injuring his crop, and that later and more careful investigations will probably show that this and several other species, but with habits that are practically the same, have been confused, and thus the present arrangement serve a practical if not a scientific purpose.

Egg.—The egg of what is supposed to be this species was described by Mr. Pergande in the Department notes as follows: Colorless, polished, and longitudinally ribbed with numerous extremely fine transverse striæ.

Larva.—Cylindrical, white, with faint yellow cast. Body composed of thirteen segments. No head and no legs. Mouth with two strong black hooks. Posterior segment of body with a pair of knob-like prominences. Length of alcoholic specimens, 0.14 inch.

Pupa.—In this stage the insect is inclosed in the hardened and brown skin of the larva and this is called the puparium. This last is bright yellowish-brown, with distinct and very finely wrinkled divisions. The two knob-like prominences in the larva are retained and are conspicuous at one extremity. The black hooks of the larva are molted with the skin and can be seen through the puparium. The obsolete mouth of the larva is withdrawn, blackened, and wrinkled. Length from 0.10 to 0.14 inch.

PREVENTIVE MEASURES.

It is doubtful if one farmer out of a thousand fully realizes the danger arising from volunteer wheat. This growth springs up in the fields in greater or less abundance, and is almost invariably left to itself, as, having no value, it is thought not worth while to bother with it. Besides, the general practice in many sections of the country of seeding the wheat lands to timothy and clover would prevent any attempt to destroy the volunteer wheat, except by pasturing, which is not considered a part of good husbandry at that season. A rotation of crop, however, has in itself some advantages, as it forces the flies to migrate from one field to another, in which there must be more or less casualties, and many more would probably be attracted to the grasses and the young fall wheat be protected to this extent from attack. Where wheat is to follow wheat in the same field, it will certainly pay the farmer to destroy this volunteer growth, as it not only harbors all of these flies and offers unusual advantages for the development of this midsummer brood, but it offers a breeding place for the Hessian fly as well. Volunteer wheat, then, should be destroyed wherever possible by the plow or disk harrow, and, where practicable, by pasturing, so as to prevent the flies from breeding therein. Burning over the grass lands, except timothy or clover, where it is probably not necessary, will offer much protection, especially in spring-wheat growing regions, and where fall wheat is much grown, reasonably late sowing will probably prove one of the most effective means of protection.

NATURAL ENEMIES.

While this species probably has its usual number of natural enemies, it is not always possible to determine the exact species from which these have been reared, but an insect that is parasitic on one species of these flies might be confidently looked for as being parasitic upon other allied species. *Rhyssalus oscinidis* Ashm. is parasitic on a species of Oscinis larvæ mining in the leaves of plantain, in Washington, D. C. *Aphæreta californica* Ashm. and *A. oscinidis* Ashm. have both been reared from other species of Oscinis, while I have reared *Cyrtogaster occidentalis* Ashm. from either this species, *O. soror*, or *O. umbrosa*, in Indiana, though it is known to occur from Texas to South Dakota and east to Virginia and the District of Columbia. These are all minute four-winged flies, and there are probably many others that also help to keep these flies reduced in numbers. I have also observed the common parasitic fungus *Entomophthora muscæ* attacking the flies, but this is probably a minor factor among their natural enemies.

THE AMERICAN FRIT-FLY.

(*Oscinis soror* Macq. Fig. 15, p. 52.)

This species has been so interminably confused with other allied species, especially with what has been going the rounds as *Oscinis varabilis* Loew? a synonym, and as frequently confused with *O. carbonaria* as with this, that it seems almost impossible to say anything about it with any degree of certainty that one is not really dealing with something else. *Oscinis soror* is, nevertheless, a valid species, and its larvæ in all probability attack growing grain, though I have myself rarely reared it from grain, and my proof of its destructiveness in wheat fields is unfortunately not as conclusive as I wish it were. The larvæ certainly have a wide range of food plants, as I have reared it from maggots in the stems of *Panicum crus-galli* in Indiana during September, and also from the stems of *Poa pratensis* in June and from wheat in July. It has also been reared from larvæ wintering in the seed capsules of *Vernonia noveboracensis* May 15 in Washington, D. C.; in June and July, at Columbus, Ohio, from oat plants; from the roots of cucumber, October 2, in Maryland; and from strawberry plants in Michigan. Last year I reared the flies from the stems of *Eragrostis minor* at Urbana, Ill., in September. These definitely authenticated rearings of the flies show a wide range of food plants, and the species is one of the most abundant of all the Oscinids.

CONFUSION WITH OTHER SPECIES.

Owing to a species having been found in Illinois and Kentucky attacking wheat and doubtfully determined by Doctor Williston as *Oscinis variabilis* Loew, now known to be a synonym of this species, and this determination having been applied elsewhere to other Oscinidæ attacking wheat, has led to much confusion, as where the name *O. variabilis* has been applied to a form committing depredations, we can not say with any degree of certainty whether the insect involved was this species or *O. carbonaria*, unless specimens actually reared from the plants so attacked are at hand. Realizing the difficulty when I began the preparation of this bulletin, I applied to Mr. Coquillett, of the United States National Museum, for suggestions as how to best overcome it and received from him an offer to determine any material reared from larvæ attacking wheat in various parts of the country. Doctor Fletcher had published accounts of the ravages of *Oscinis variabilis* Loew? in Canada, Dr. Otto Lugger of similar ravages of *Oscinis soror* in Minnesota, and Professor Garman of the attacks of *Oscinis variabilis* Loew? in Kentucky. Application was therefore made to Doctor Fletcher, Professor Washburn, successor to the late Doctor Lugger in Minnesota, and Professor Garman, for reared material in order to as far as possible place the responsibility for these depredations

on the species actually engaged therein. Material kindly placed at my disposal by Doctor Fletcher has shown that it was *Oscinis carbonaria* Loew that committed the depredations in Canada. Professor Washburn was less fortunate, though he did all that was possible for him to do to aid me, and sent specimens that, judging from the labels attached, had been reared by Doctor Lugger, but whether from wheat or not it is impossible to determine, as nothing could be found that would throw any light upon this point. The specimens sent me from Minnesota by Professor Washburn comprised two species, *O. soror* and *O. dorsata* Loew, the former having been supposed by Doctor Lugger to have been responsible for the injuries to wheat in Minnesota in 1892, while the latter was reared by me from wheat plants in Ohio in the fall of 1897, thus indicating that both might have been involved in the Minnesota trouble. Assuming that Doctor Lugger had sufficient grounds for holding *Oscinis soror* responsible for the damage in his State at the time stated, I have so considered it here, but have thought proper to indicate the uncertainties surrounding this conclusion. Not being able to secure any material whatever from Professor Garman, I am forced to reluctantly place the blame for the outbreak in the wheat fields in Kentucky in 1889 upon *Oscinis soror*, but with a strong suspicion that it was really *Oscinis carbonaria* that was responsible for the trouble. I have applied Doctor Lugger's descriptions of the larva and pupa to this species as being the best that can be done with our present knowledge of these insects, but subject to revision, as future investigations shall clear up more or less of the obscurity at present surrounding them.

DEPREDATIONS IN MINNESOTA.

There is one fact connected with the Oscinis problem in Minnesota that seems to point especially to *O. soror* as the real depredator, and not *O. dorsata*, and that is in the striking difference in the color of the two, the former being black and the latter yellow, a difference that could hardly have escaped the keen eyes of Doctor Lugger, and I can not but feel that he was correct in his attributing the depredations to the species now being considered. I strongly suspect that some of the "deadheads" to which Doctor Fletcher has called attention in his reports and other publications as occurring in the wheat fields of Manitoba and the Northwest Territories may have been to some extent due to the work of this species also.

Doctor Lugger seems not to have studied the several generations of the species in his State (Minnesota), but gave his attention especially to the one that proved the most destructive. From what has been stated of the insect farther to the southward, it would appear that there are the same number of broods as with *O. carbonaria*, the pest wintering over in the young plants of fall wheat and grass. In Minnesota it evidently winters in the straw, from which it would seem

that in the north there is one less brood than there is farther to the south, a condition of affairs entirely possible, as we now know that the Hessian fly is there largely at least single brooded, but double brooded farther south. In his second annual report as State entomologist, pages 6 to 10, Doctor Lugger gives these facts relative to the work of the insect in his State:

During the summer and early part of the fall numerous letters were received from many parts of the State in which the writers complained about minute worms which infested the stems of wheat just above a joint from 3 to 4 inches above the ground. The specimens received at the same time showed that, as a general rule, the first and second joints of the plant were infested. Some farmers complained that their crop of wheat was thus very materially reduced. The plants harboring the worms did not indicate their presence until flowering time, but as soon as the head began to form the stem above the injured joint wilted, turned yellowish, and soon broke down entirely by bending over the infested spot. * * * But when the infested stems were investigated it was found that the worm had weakened them to such an extent that when the head was formed the plant became topheavy and broke down at the weakest point from force of gravity. * * * These heads were either entirely empty or filled with berries more or less shrunken. The bent or partly broken stems were, as a general rule, still adhering to the lower portion of the plant. This bending or breaking had taken place most frequently above a node or joint about 3 inches from the ground. Just below this breakage, and immediately above the joint, the culprits were to be found. In most cases but one puparium, but in a few cases two, three, or even more puparia could be detected. Such a puparium is the contracted and hardened skin of the larva or worm; it is of a glossy, chestnut-brown color, shading to yellowish brown toward the smaller end. If closely inspected it shows faint traces of sutures or segments. * * * These seed-like objects contain at this time (October) whitish larvæ or worms, and no pupæ have been detected inside of them up to this date. * * * Judging from the fact that only pupæ [puparia?—F. M. W.] can be found at this time, it would appear as if this insect hibernates in that stage. This is really the only one in which it could well pass our northern winters, being in that stage well protected by its old and thickened skin and by the stem of the plant. The puparia are inserted in the material of the upper part of the node, inaccessible to any moisture from the outside, as the stem above does not break off entirely, but simply bends in a more or less acute angle a short distance over them, thus preventing the entrance of water. Yet the culm is sufficiently fractured to permit a free exit of the future fly in spring. * * *

The damage caused by this insect in 1892 was by no means small. In many places fully one-fourth of the entire crop of wheat was destroyed, and in a great many more the losses amounted to at least one-tenth. As many places are badly infested, the total amount is quite large, and if no steps are taken to prevent it a repetition may become ruinous in 1893. Most farmers plowed their fields in the fall of 1892 or early in 1893, and consequently the losses in the latter year were small, and in 1894 but very few of these insects were to be found. The spring of this year [1896?—F. M. W.] being very wet, prevented extensive plowing, and the insects, not being disturbed or plowed under, again became a pest and caused considerable damage. The name "frit-fly" is a well-deserved one, as Swedish farmers call the worthless grain resulting from the attack of such flies "frits."

LIFE HISTORY.

As stated by Doctor Lugger, the life history is still very obscure, and it will require careful study and close observation to secure a knowledge

of it over the country. The facts given by him in his report are unlike what has been observed farther south, but these differences are not sufficient to indicate that it was not this species that caused the injuries mentioned. Even if we assume that the insect reared in Kentucky by Professor Garman belonged to this species, we find that adult flies have been reared by others in May, late June, and early July, and again in September, thereby indicating three broods in the vicinity of latitude 40°, the species wintering as larvæ or pupæ, probably the latter, the flies emerging from these ovipositing in May, the adults from these appearing in June and July, these in turn giving origin to a fall brood in September, whose progeny winter over as stated. In more northern and inland sections of the country it seems that the fall brood may drop out and the one occurring farther south in midsummer pass the winter as puparia and the adults emerge the following spring.

FOOD PLANTS.

Either this has a greater range of food plants than *Oscinis carbonaria*, or else we have not learned much about those of the latter. As it is, the food of this species is so varied as to almost incline one to the suspicion that it stands accused of ravages that should be placed to the credit of another but for the facts supplied by Doctor Lugger. However, this variation in its bill of fare gives the farmer a still better opportunity of fighting it outside his grain fields.

DIFFICULTIES IN STUDYING HABITS.

The fact that maggots taken from wheat plants in a field develop these flies does not necessarily prove that other maggots attacking wheat in the same field will produce the same species of flies; therefore, descriptions drawn up from such collections may or may not be correct, and for the same reasons observations on the habits of such larvæ are liable to be incorrect. It is only by placing flies on plants known to be free from all other infestation and studying these that we shall be able to get at the truth in relation to anatomical and biological facts. An investigator will then know just which species he is dealing with, and whatever descriptions are drawn up from material secured in this manner and whatever observations are made upon them will be sure to be accurate so far as the species under observation is concerned. In no case has this been done, and as a consequence we have only a general knowledge of these insects, and any descriptions of the larvæ may or may not prove correct in future. Though there is a noticeable difference between the adult figured by Doctor Lugger as this species and the one figured by Professor Garman as *Oscinis variabilis* Loew? the figures of the larva and puparia are exceedingly alike. For the same reason any recommendations looking to the control of the pest

in the grain fields must be made somewhat at random and aimed at Oscinidæ in general rather than at this particular species.

REMEDIAL AND PREVENTIVE MEASURES.

Over the area where winter wheat is cultivated the same measures that have been urged against the two wheat stem-maggots will apply equally well here, so far as we now understand the habits of this species. These are the destruction of volunteer wheat, the burning over of waste grass lands in winter and early spring, and late sowing of the grain in fall. In spring-wheat regions the experience of Doctor Lugger in Minnesota is strongly indicative of the effect of plowing the infested fields as soon as possible after the crop has been removed. He states that in the fall of 1891 and spring of 1892 not more than one-half of the acreage of wheat land was plowed, owing to unusually wet weather during these periods, and the pest that had gained a foothold, as it were, in 1891, meeting with no reverses on account of lack of plowing, simply continuing to increase in numbers, with the result that in 1892 it committed serious and widespread depredations. Where the fields can be burned over in fall or spring the result will, of course, be the extermination of the pest in such fields in the northern portions of the country, but farther south it is the grass lands that need to be burned over, since there is no way of reaching the insect hibernating in the winter-wheat plants. The fields of spring wheat in the North will, of course, be to some extent also protected by the burning over of the grass lands in fall or spring.

DESCRIPTION.

The difference between this species and *Oscinis carbonaria* have already been pointed out in the treatment of the latter species (see p. 55).

Larva.—This very closely resembles that of *O. carbonaria*, as is shown by the illustrations used by Doctor Lugger in his publications. He states, however, that the larva is of a greenish-white color when alive and just removed from the culm.

Puparium.—Here, again, it would be difficult to identify the puparium by either the illustration or description given by Doctor Lugger, as both closely resemble those given of *O. variabilis?* by Professor Garman. Doctor Lugger describes this as being of a glossy chestnut-brown color, shading to yellowish brown toward the smaller end, and showing faint traces of sutures or segments.

Of the other species of small Oscinidæ whose larvæ are found in and about the stems of growing grain I have already written, and it is impossible with our present knowledge of them to go into further details. Some of these may be destructive and some may not, as the fact of these having been reared from grain plants does not necessarily

prove that they are destructive, as they may live upon the dead and decaying older leaves or they may simply inhabit the burrows made by other insects. The practical farmer will probably be able to meet their depredations by the same measures that have been recommended for those species with which we are the most familiar, at least until a more extended study can be made and more light thrown on their habits.

CONCLUSION.

In the foregoing it has been the aim of the writer to so present this subject as to enable the farmer to distinguish some of the more obscure enemies of his crops and prevent a peculiar and subtle shrinkage in the profits of his labors, and one that he can meet in most cases by simple measures that cost nothing except the time consumed in carrying them out during seasons or days of comparative inactivity on the farm. Not all of the ravages in the wheat fields are due to the Hessian fly, and, indeed, the crop reports are usually wholly unreliable in respect to the actual occurrence of this insect, except it be in cases of overwhelming numbers. One of the most practical preventive measures that can be applied against the Hessian fly will also prove of value in warring against these other pests, viz, late seeding of fall wheat in autumn; and a second measure, that of rotation of crops, will be found almost as valuable. Fighting insects demands a better system of farming, which of itself will pay in other directions, and the American farmer must calculate upon insect depredations as no small element in his business. Of what use is it to rear two blades of grass where but one grew before if he is to lose both of them by reason of insect attack? It is not the farm but the profits thereof that are lost through the devastations caused by injurious insects, and it costs the American farmer more to feed these insidious foes than it does to educate his children.

O